POWER

Vol. 37 JANUARY 14, 1913 No. 2

Beware the Imp of Indolence!

AFTER the novelty of the new job wears off, nothing makes the engineer's life one dreary monotonous daily grind like the Imp of Indolence. The first thing an engineer knows, he is overpowered by the Imp and has his nose to the grindstone.

Many laymen have an idea that the life of an engineer is one of ease, with nothing to do but watch the wheels turn. This apparent visible evidence that the engineer's life is a "snap," leads many young men into the profession who realize in the course of years that it requires time and study to keep up with the procession, let alone get ahead of it so as to put himself in line for something better when the opportunity comes.

So day after day, and day after day, these misguided novices perform the same routine work in a plant where there is every opportunity to make a record for performance; they overlook the all-important fact that to achieve any measure of success they must know not only what has been done in the past, but they must keep posted as to what is being done now in the line of the generation and transmission of power.

Surrounded almost and certainly within easy reach of an abundance of excellent and authentic reading matter to relieve their difficulties, they keep on in the same old way, day by day, with their noses to the grindstone, heedless of the available literature to lighten their burden.

There are many men also who take trade papers and own books relating to power plant subjects, but who never take the time to glance at their valuable contents. These engineers are no better off than those who do not subscribe for engineering journals at all, and who do not own so much as a book on power generation.

Don't let the Imp of Indolence keep your nose to the grindstone. Break away from his grasp; then reading and studying will lead the way to success where the monotonous daily grind is replaced by a position wherein executive ability is required and where one has a larger field in which to develop himself and show his worth.

[*Contributed by George H. Wallace, Racine, Wis.*]

New Perth Amboy Central Station

By Warren O. Rogers

SYNOPSIS—Description of a new central station having many features worthy of notice. The method employed in cutting in and out turbines and exciters by illuminated signals is one of them.

The Public Service Corporation of New Jersey controls three distinct enterprises, the Public Service Gas Co., the Public Service Railway Co., and the Public Service Electric Co. The last is divided into three divisions, known as the Northern, Central and Southern, each operated under a separate management. The Perth Amboy station is in the central division and works in conjunction with the seven other generating stations of that division. In Fig. 1 is shown the relative location of stations and substations. The main circuits are all of 13,200 volts and the load is composed of power, lighting and street-railway service.

The station has been built on the west bank of the Arthur Kill, which facilitates the delivery of coal by water and also affords an abundant supply of salt water for condensing purposes. Fig. 2 shows a view of the station from the water front at low tide, also the conveyor runway and condensing-water intake.

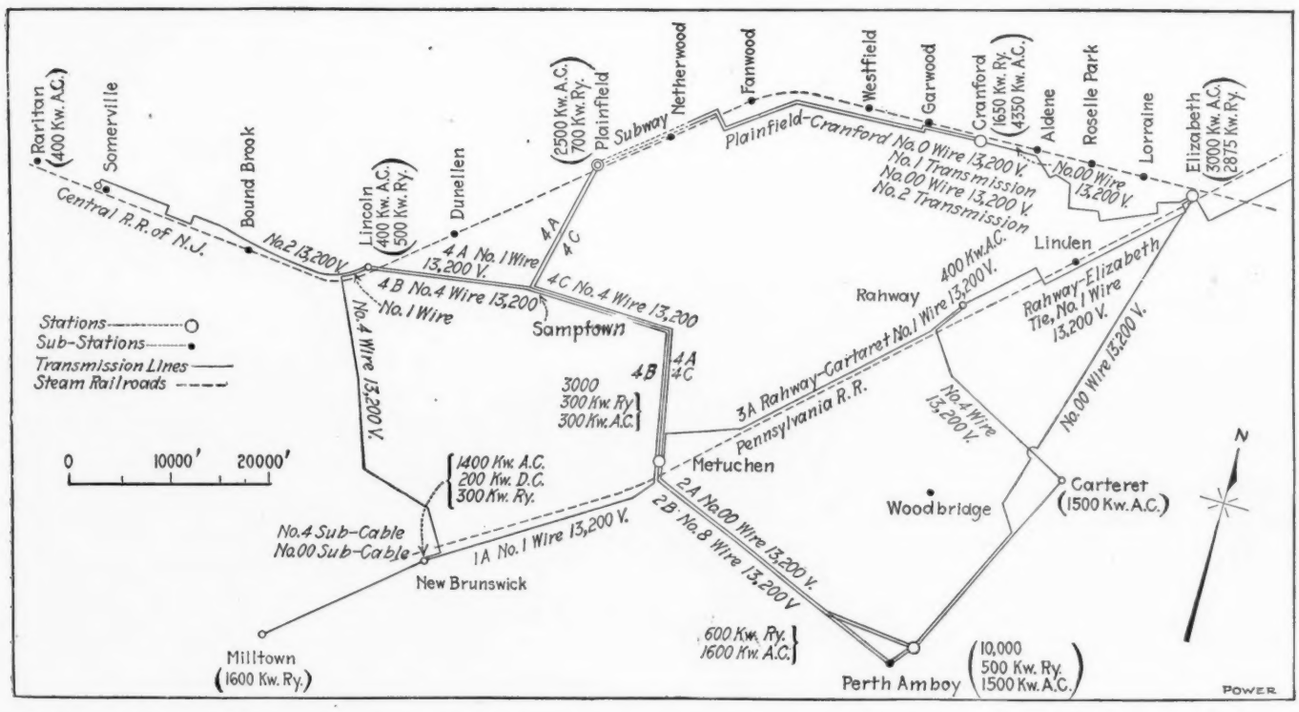


Fig. 1. Showing Relative Location of Power Plants and Substations of the Southern Division of the Public Service Co.

The building is constructed of red brick with terra-cotta trimmings. It is divided into a boiler and a turbine room, each having a large, well lighted basement. The turbine room has a gallery at one end where the engineers' offices are located. It is built with a temporary end to permit of extending the building eventually.

The inside walls are yellow pressed brick. The turbine-room floor is concrete with gratings between the turbines, giving a view of the condensing outfit. A monitor roof provides light and ventilation. At night, the room is illuminated by eight inclosed arc lights and 120 sixteen-candlepower lamps hung from girders; the auxiliary rooms with incandescent lamps. A 35-ton box crane runs the length of the turbine room.

Turbines and Exciters

There are two double-flow turbines which run at 1800 r.p.m., each driving a 5000-kv.-a., three-phase, 60-cycle alternating-current generator with a voltage of 13,200. These machines are set crosswise of the turbine room as in Fig. 3, on a foundation of steel piers inclosed in concrete, shown in Fig. 10. The governor oil pressure is maintained at 44 lb. and that on the bearings at 5½ lb. The machines are fitted with a tachometer. Two auxiliary bearing oil pumps are used when starting and stopping. Each generator has an individual slate switchboard on the turbine-room floor upon which the field generator switches and circuit-breakers are mounted.

Three turbine-driven exciter sets are placed in a bay at the head of the turbines, Fig. 4. The generators are of 800 amperes capacity at 125 volts, with a speed of 2400 r.p.m.

Heaters and Recording Instruments

At the other end of the same bay are two open feed-water heaters, using the exhaust steam from the auxiliary units about the plant.

On the wall behind the heaters is located the recording instrument board, containing two recorders for feed wa-

ter temperature, two for vacuum, one for steam pressure and one for steam temperature. There are also two venturi-meters, recording and indicating the quantity of water used in the boilers.

Boiler Room

In the boiler room, which is separated from the turbine room by a brick wall, the entrance through which is protected by fireproof metal doors, are eight 600-hp. water-tube boilers fitted with superheaters. Each boiler has 294 tubes, 18 ft. long, and three 42-in. drums, 20 ft. 4 in. long. A view through the firing alley between the four batteries of boiler is shown in Fig. 5.

Fig. 2. Waterfront View of the Station, Showing Coal-conveyor Runway and Condenser Intake

Coal is delivered to the 1500-ton capacity concrete coal bunker, above the boilers, by a 400-ft. belt conveyor, running from the wharf to the power plant through a runway, as shown in Fig. 2. From the storage bin the coal runs through spouts, each fitted with a weighing scale and into the stoker hopper as wanted. All charges weigh 1600 lb. and tally is kept by the fireman on a registering clock each time a new charge is weighed. The register is checked at the end of every shift. The coal is unloaded from barges by a clamshell bucket, operated by a steam hoisting engine, and dumped into a hopper above a coal crusher operated by a 10-hp. induction motor. The belt conveyor is operated by a 30-hp. induction motor.

A view of the back of the boiler setting is shown in Fig. 7. Each of the 24 blowoff pipes contains a plug cock and a blowoff valve of the gate type. The smoke uptake from each boiler connects with a separate main smoke flue, running along the rear and above each row of boilers to the two brick chimneys.

The draft of each battery of boilers is controlled by a damper regulator. If the plant is running with a light load with only a small part of the boiler capacity under steam, hand regulation is adopted, as there is sufficient natural draft for eight boilers on each chimney. With full boiler load forced draft is used, each set of four boilers being served by a 10-ft. fan driven by a 12x14-in. engine. These units are set, one under each stack between the four steel and concrete columns which support the chimney, as shown in Fig. 6. Air is carried to the furnaces through a sheet-iron air duct, supported by the basement ceiling, branches going to each furnace. These chimneys, contrary to the general practice of using a solid foundation, set on four steel columns incased in concrete, upon which I-beams are set and which support a concrete base, Fig. 6. The chimneys are 179 ft. high and 14 ft. in diameter at the top. Both chimneys are at the end of the boiler room having the temporary end-wall construction, but the doubling of the boiler installation will make them central in the boiler room, the duplicate smoke flues entering from opposite sides of the stack.

Refuse from the ashpit is loaded into an ash car in the basement, as shown in Fig. 8, and at present is removed to the yard and used for filling-in purposes. The stoker shafts are motor driven, but a vertical steam engine is also installed for each and connected to the stoker eccentric shaft by a belt and clutch. The stokers are operated from the shaft eccentrics by an eccentric-rod. The two shafts and the motor which drives them are hung from the basement ceiling.

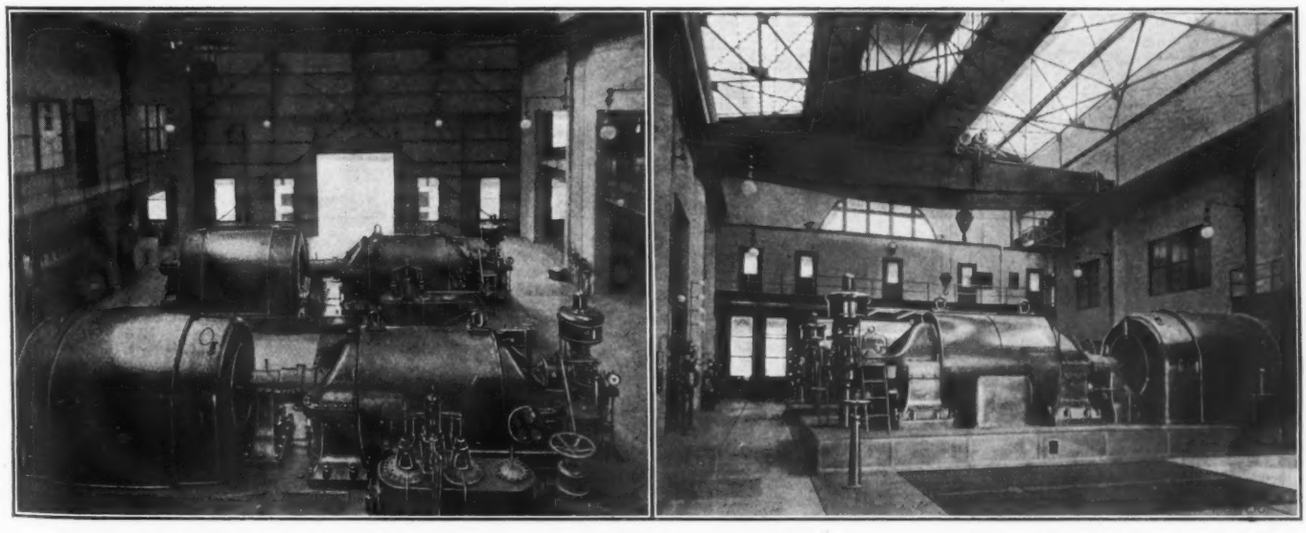


Fig. 3. Two Views of the Turbine Room of the Perth Amboy Station

Feed-water Pumps

Water is supplied to the boiler by three 80-hp. steam-turbine-driven centrifugal pumps, running at 2400

r.p.m. These are in the basement, under the feed-water heaters, which are on the floor above.

Two 6 and 4 by 6-in. duplex oil pumps handle the oil from the two filters. The house water supply is handled by one of two 10 and 6 by 12-in., outside-packed, duplex pumps, pot-valve type. On the same floor is an 18 and 10 by 12-in. underwriters fire pump with a capacity of 1000 gal. at 70 r.p.m. A view of the pump room, with the turbine-driven centrifugal pumps in the distance, is shown in Fig. 9.

A 9 and 10 by 12-in. steam-driven air compressor furnishes compressed air for plant use and is placed at one end of the basement where a plant machine shop has also been installed.

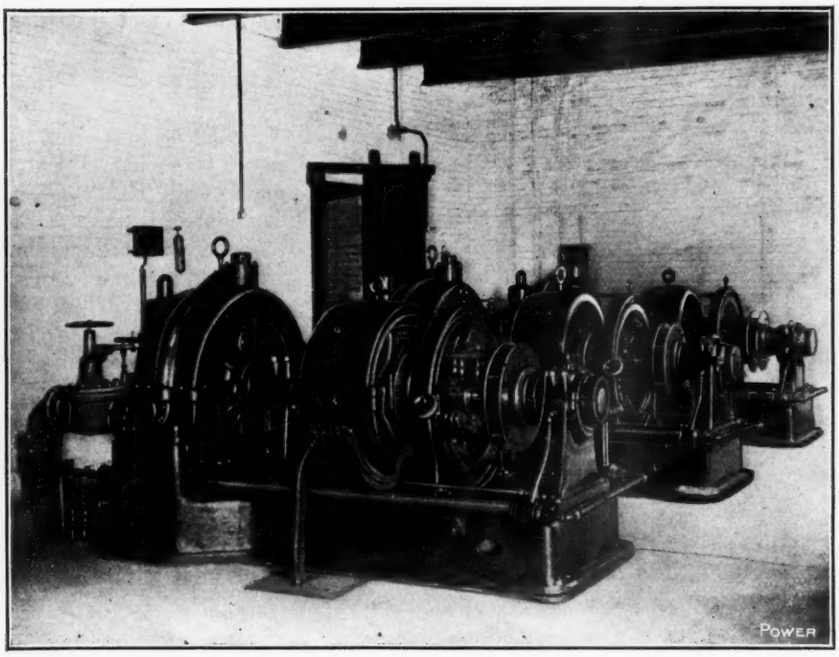


FIG. 4. STEAM TURBINE-DRIVEN EXCITER UNITS

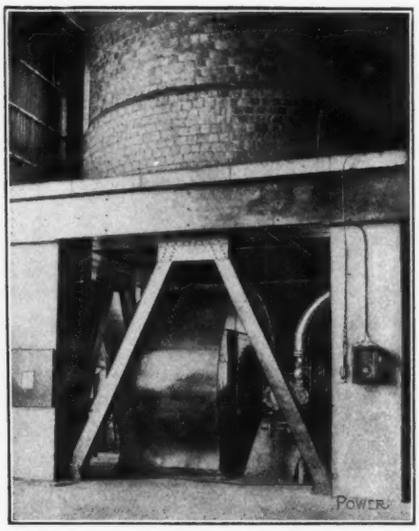


FIG. 6. FORCED-DRAFT FAN, CHIMNEY AND FOUNDATION

CONDENSERS

Two surface condensers, each containing 10,000 sq.ft. of cooling surface, are in the basement, one directly under each turbine. Each condenser is served by a 12 and 22 by 18-in. rotative dry-air and vacuum pump and a circulating unit consisting of a 20-in. three-impeller centrifugal pump directly connected to a 36-in. steam turbine; the hotwell pump is 4 in., directly connected to a

FIG. 5. VIEW THROUGH FIRING ALLEY

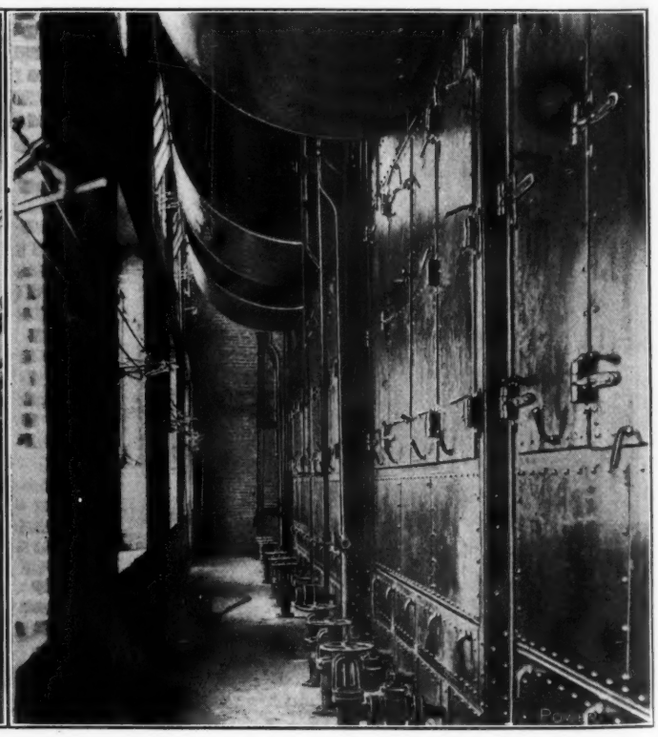


FIG. 7. BLOWOFF PIPES AND SMOKE UPTAKES

steam turbine. A feature of their installation that should appeal to engineers is that both condenser units are placed between the four concrete-supporting piers, as shown in Figs. 10 and 11, thus occupying a minimum of floor area other than that occupied by the turbine foundations.

Each circulating pump takes water from two lines of 6-ft. concrete intake pipe which run from a point beneath the plant to a natural forebay outside of the plant. There is also a 10-ft. concrete circulating water-discharge canal. Each equipment is guaranteed to condense 75,000 lb. of steam per hour and produce a vacuum of 28 in. with circulating water at 70 deg. F., or 28½ in. vacuum with the circulating water at 60 deg. F.

operated from the main and local switchboards respectively.

The main generator and transmission line switches and switchboard are in the gallery above the turbine room, Figs. 12, 13 and 14, and the local commercial and railway circuits are controlled from switchboards in a bay of the turbine floor, opposite the exciter bay.

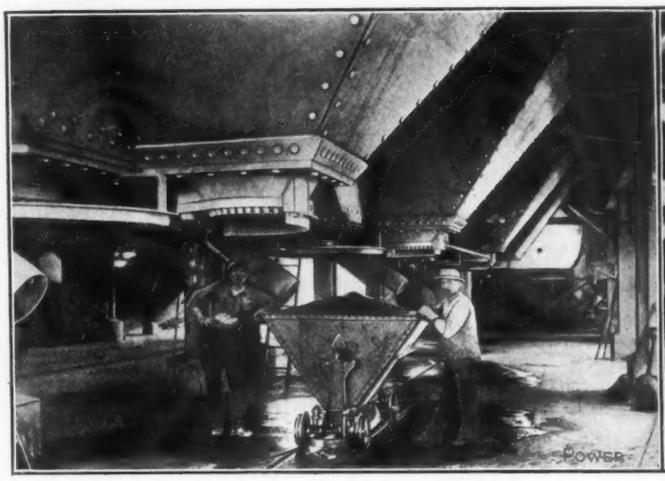


FIG. 8. METHOD OF HANDLING ASHES

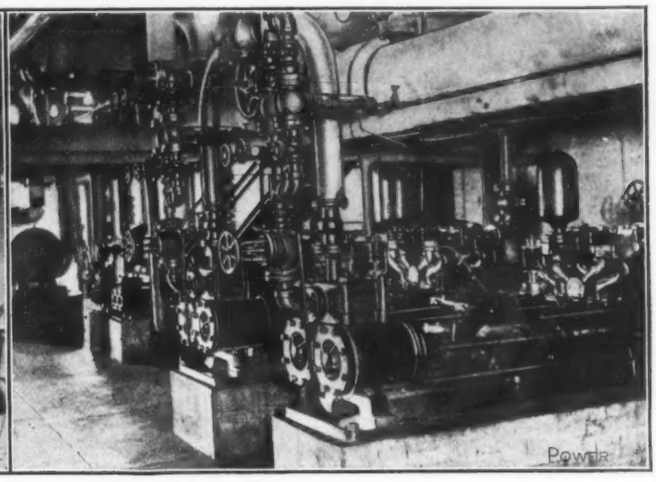


FIG. 9. VIEW OF THE PUMP ROOM

ELECTRICAL APPARATUS

In addition to the turbo-generators and exciters, the station is equipped with one 1000-kv.-a. oil-immersed, water-cooled transformer and one 500-kv.-a. oil-cooled transformer for supplying local service at 2400 volts, two-phase. There is also one 500-kw. 60-cycle rotary converter supplying direct current for railway use at 600 volts. All transformers are installed in the basement.

All 13,200-volt and 2400-volt switches are electrically

The 13,000-volt electrolytic arresters are located on a gallery above the main high-tension switch-room, Fig. 15, at which point the transmission lines enter the building.

SIGNAL SYSTEM

The turbines and exciters are controlled with reference to a system of illuminated signals. In the boiler room an illuminated signal board is suspended where it can be readily seen by the men, and designates the load being carried. If the load is to be changed, the switchboard operator signals the boiler room by blowing one blast of a signal whistle and setting a dial to illuminate the figures indicating the load in kilowatts to be carried within the next 15 min. The signal remains illuminated until the next change in the load occurs.

In the turbine room is a column of lights numbered to correspond with the turbine and exciter numbers, and a

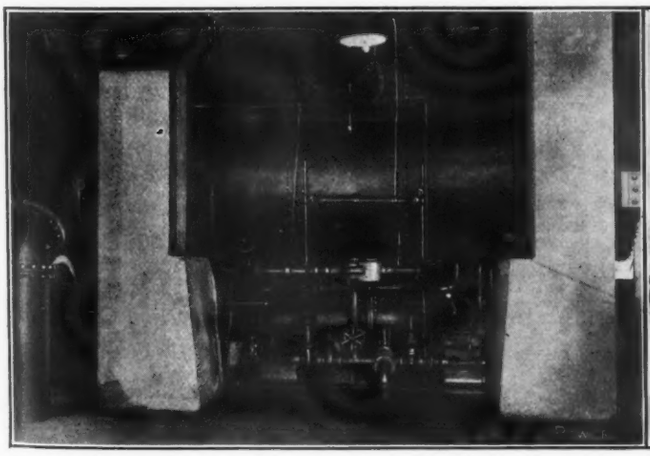


FIG. 10. CONDENSER AND AIR PUMP

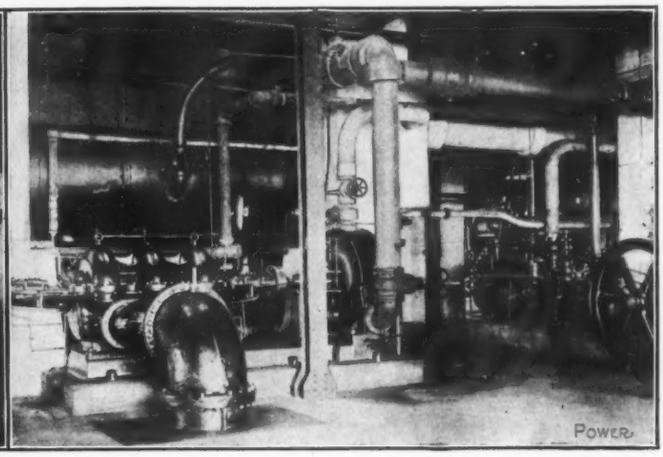


FIG. 11. CONDENSER CIRCULATING PUMP

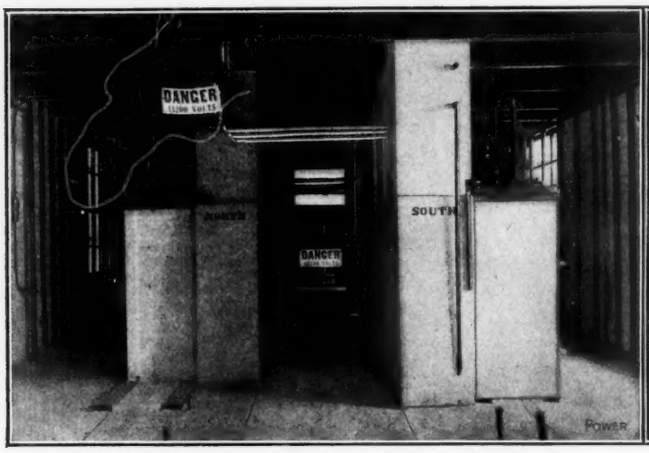
keyboard at the head of each turbine which corresponds with one on the operating board. The signals consist of six illuminated disks, "Full Speed," "O. K.," "Shut Down," "Start," "Stand By" and "Load Off."

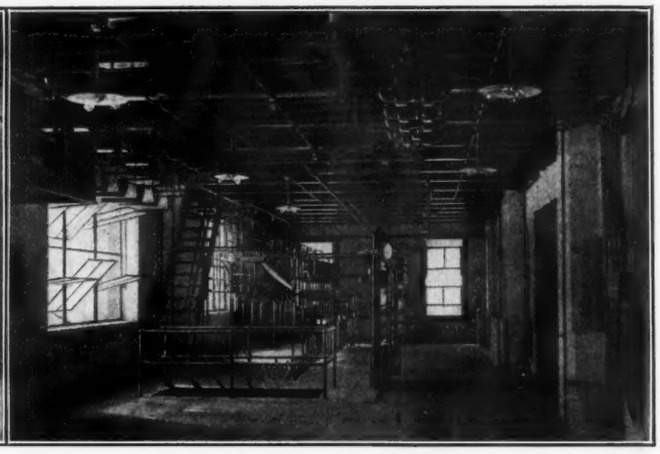
If the operator wishes to start a turbine, one blast of a whistle is blown and the number of the machine wanted is illuminated. At the same time the dial "Start" is illuminated on the panel of the generator to be put in service.

The engineer answers by pressing a button switch which illuminates the dial "O. K." As soon as the machine is ready for the load he also gives the signal "Full Speed," and at the same time cuts out the signal "O. K." The operator then gives one blast of the turbine-signal whistle and signal "Stand By" which is answered by the engineer with the "O. K." signal.

After the operator has synchronized the machine with those running he throws in the generator oil switch and switches off all signals and gives the "O. K." The engineer does the same from his panel.

When shutting down a turbine the signal whistle is blown one blast and the number of the machine to be shut down illuminated, also the order to "Stand By" given, the engineer answering "O.K." The operator then throws out the generator oil switch and signals "Load Off," when the engineer stops the turbine. As soon as the operator gets the signal "Shut Down," he cuts out the signal "Load Off," indicating "O. K." to the engineer who in turn switches off the signal "Shut Down."





FIGS. 12 AND 13. OIL-SWITCH AND TRANSFORMER ROOMS

In case the engineer wishes to shut down a unit because of accident, etc., he pushes an emergency buzzer in the operator's room and signals "Shut Down." The operator then gives the signals the same as for starting a machine under ordinary conditions and cuts out the defective machine as soon as another has picked up the load, signaling "Load Off" on the signal board belonging to the defective machine. When the engineer has the defective machine shut down, he switches off the signal "Shut Down" and the operator switches off the signal "Load Off," leaving the panels clear.

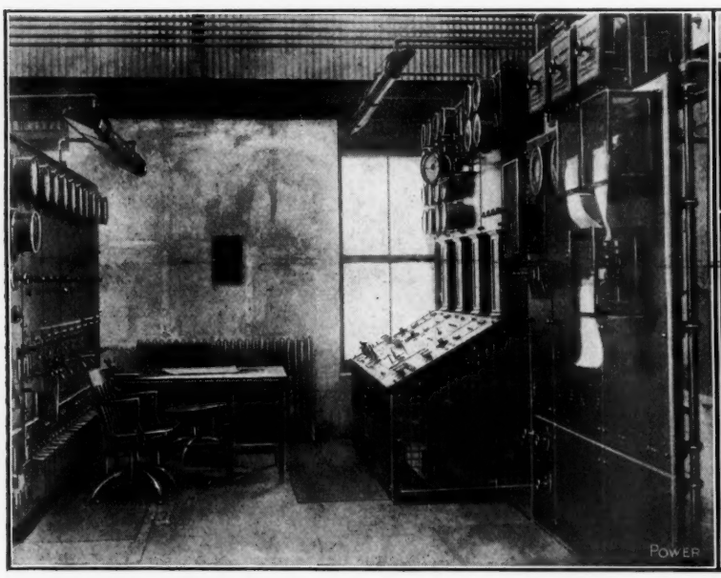


FIG. 14. OPERATING SWITCHBOARD

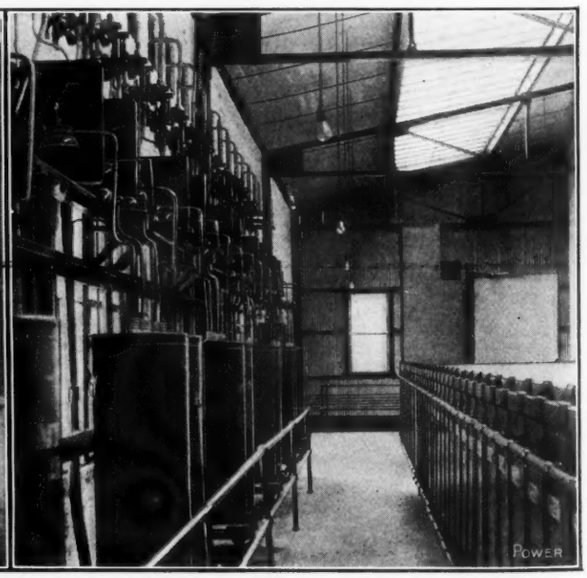


FIG. 15. LIGHTNING-ARRESTER ROOM

When the operator desires to put a turbine under load quicker than under normal conditions, he notifies the engineer by giving four blasts of the whistle in rapid succession and the signals for starting up are given as under ordinary conditions.

The same signals answer for starting and shutting

EQUIPMENT OF THE NEW PERTH AMBOY CENTRAL STATION

No.	Equipment	Make	Purpose	Kv.a.	Kw.	Volts	Amp.	Phase	Cycles	R.p.m	Size	Pres. lb.	Hp.	Manufacturers
2	Steam turbines	Double flow	Gen. units	..	5000	...	..	...	..	1800	.....	190	...	Westinghouse Machine Co.
3	Steam turbines	Single Stage	Exciter sets	..	100	...	..	...	..	2400	.....	190	...	Westinghouse Machine Co.
3	Steam turbines	Single Stage	Feed pumps	..	...	...	..	...	..	2400	.....	190	80	Kerr Turbine Co.
2	Engines	Center Crank	Fans	..	...	...	..	...	..	..	10'	...	...	Buffalo Forge Co.
2	Engines	Vertical	Stokers	..	...	...	..	...	..	..	.....	...	...	Troy Engine & Machine Co.
1	Engine	Hoisting	Coal bucket	..	...	...	..	...	..	..	12x14"	...	...	Mead-Morrison Mfg. Co.
1	Compressor	Steam driven	Air	..	...	...	..	...	..	..	9x10x12"	...	...	Chicago Pneumatic Tool Co.
8	Boilers	Water tube	Main units	..	...	...	..	...	..	..	.....	190	600	Babcock & Wilcox Co.
8	Stokers	Chain grate	Boiler furnaces	..	...	...	..	...	..	..	.....	...	...	Babcock & Wilcox Co.
2	Generator	Alt. current	Main units	5000	...	13,200	219	3	60	1800	.....	...	...	WestinghouseElectric and Mfg.Co.
3	Generators	Direct current	Exciters	..	100	125	800	..	..	2400	.....	...	...	WestinghouseElectric and Mfg.Co.
1	Converter	Rotary	Railway	..	500	600	833	6	60	900	.....	...	...	WestinghouseElectric and Mfg.Co.
1	Turbine	Alberger	Circulating pump	..	...	...	...	..	..	..	36"	...	...	Alberger Pump and Condenser Co.
1	Turbine	Alberger	Hotwell pump	..	...	...	...	..	..	..	.....	...	...	Alberger Pump and Condenser Co.
1	Motor	Induction	Coal crusher	..	...	220	44	2	60	1200	.....	...	20	General Electric Co.
1	Motor	Induction	Coal conveyor	..	...	220	82.8	2	60	1150	.....	...	30	Westinghouse Electric & Mfg. Co.
1	Pump	Duplex	Fire	..	...	...	..	...	..	..	18x10x12"	...	...	International Steam Pump Co.
2	Pumps	Duplex	Oil	..	...	...	..	...	..	..	6x4x6"	...	...	Dean Bros. Steam Pump Works
2	Pumps	Duplex	House supply	..	...	...	..	...	..	..	10x6x12"	...	...	Dean Bros. Steam Pump Works
3	Pumps	Centrifugal	Feedwater	..	...	...	..	...	..	..	No. 3	190	...	Platt Iron Works Co.
2	Pumps	Rotative	Dry vacuum	..	...	...	..	...	..	..	12x22x18"	190	...	Alberger Pump & Condenser Co.
2	Pumps	Centrifugal	Hot well	..	...	...	..	...	..	..	4"	...	...	Alberger pump & Condenser Co.
2	Pumps	Centrifugal	Circulating	..	...	...	..	...	..	..	20"	...	...	Alberger Pump & Condenser Co.
2	Condensers	Surface	Turbines	..	...	...	..	...	..	..	10,000 sq.ft	...	...	Alberger Pump & Condenser Co.
2	Heaters	Open	Feed water	..	...	...	..	...	..	..	No. 7	...	...	Platt Iron Works Co.
1	Conveyor	Belt	Coal	..	...	...	..	...	..	..	400 ft.	...	...	Robins Conveying Belt Co.
2	Chimneys	Kellogg	Boilers	..	...	...	..	...	..	..	179 ft.	...	...	M. W. Kellogg Co.
2	Recording meters	Venturi	Feed water	..	...	...	..	...	..	..	6 in.	...	...	Builders Iron Foundry
3	Temperature and pressure gages	Recording	Steam and Water	..	...	...	..	...	..	..	.....	...	...	Bristol Co.
2	Fans	Horizontal discharge	Draft	..	...	...	..	...	..	..	.....	...	...	Buffalo Forge Co.
1	Regulator	Carmichael	Damper	..	...	...	..	...	..	..	.....	...	...	John Bushnell & Co.
4	Tachometers	Direct coupled	Speed indicator	..	...	...	..	...	..	..	.....	...	...	Schaeffer & Budenberg Mfg. Co.
2	Filters	White Star	Oil	..	...	...	..	...	..	..	.....	...	...	Pittsburgh Gage & Supply Co.
	Electrical apparatus			..	...	...	..	...	..	..	.....	...	...	Westinghouse Electric & Mfg. Co.
24	Valves	Simplex	Blowoff	..	...	...	..	...	..	..	.....	...	...	Pratt & Cady Co.

down the exciter units, except that the exciter numbers are used instead of the turbine numbers.

Pipe Color Scheme

Another interesting feature is the pipe-color scheme, all pipes used for the same kind of service being painted the same color. All high-pressure steam pipes are white; exhaust-steam pipes, buff; fresh-water, low-pressure, blue; fresh-water, high-pressure boiler feed, blue with white band; salt water, green; oil delivery and discharge, brass or bronze yellow; air lines, gray; fire lines, red; electric lines, black and red border or fittings

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The Water-Glass Method of Testing Leakage

In an appendix to its report submitted at the last meeting, the Committee on Tests of the American Society of Mechanical Engineers suggests the following test for leakage. It is so simple that anyone may make it, and it sometimes leads to surprising results.

The water necessary to restore the water level to its height when the test was started, or which is pumped in during the test to maintain the level constant, is the amount of water evaporated, if for a given height of water in the glass there is the same amount of water in the boiler before and after the test. This may not be the case if the rate of evaporation is different, and, for the same amount of water contained, the water level is raised or lowered by the presence in the water of more or less steam bubbles. Again it may not be the case if there is a change in the relative density of the contents of the boiler and the water column. If the water column is allowed to stand without blowing until the water becomes cold, its contents will be denser and it will take a shorter column to balance the hot water in the boiler than if it were at a higher temperature. For the same height of water in the boiler the water in the gage glass will stand higher than after the contents of the column become cool. This is the reason for the recommendation that the water column should not be blown down during a water-gage test nor for a period of at least one hour before it begins.

Of the water evaporated some may be:

Lost through leakage.

Condensed in the steam pipe.

Drawn off for use.

If it is desired to determine one of these quantities, the others must be eliminated or known. If it is wished to know how much is lost by leakage, for example, it is best to eliminate the third item by not drawing any of the steam out of the system under test. The difference between the amount evaporated, as determined by the difference in the water level and the amount condensed in the pipe, is the leakage. The condensation must be drawn off and weighed. Of course it must be allowed to cool to below 212 deg. before it is exposed to the atmosphere. The appendix referred to is as follows:

To determine the leakage of steam and water from a boiler and steam pipes, etc., the water-glass method may be satisfactorily employed. This consists of shutting off all the feed valves (which must be known to be tight) and the main feed valve thereby stopping absolutely the entrance or exit of water at the feed pipes to the boiler; then maintaining the steam pressure (by means of a very slow fire) at a fixed point, which is approximately that of the working pressure, and observing the rate at which the water falls in the gage glasses. It is well, in this test, as in other work of this character, to make observations every ten minutes, and to continue them for such length of time that the differences between successive readings attain a constant rate. In many cases the conditions will have become constant at the expiration of fifteen minutes from the time of shutting the valves and thereafter the fall of water due to leakage of steam and water become approximately constant. It is usually sufficient, after this time, to continue the test for two hours, thereby obtaining a number of half-hourly periods. When this test is finished, the quantity of leakage is ascertained by calculating the volume of water which has disappeared, using the area of the water level and the depth shown on the glass, making due allowance for the weight of 1 cu.ft. of water at the observed pressure. The water columns should not be blown down during the time a water-glass test is going on, nor for a period of at least one hour before it begins.

If there is opportunity for condensation to occur and collect in the steam pipe during the leakage test, the quantity should be determined as closely as desirable, and properly allowed for.

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The industrial prominence of Pittsburgh is seen by its fuel consumption. More fuel is consumed in Pittsburgh and its immediate vicinity, and more coal is shipped to and through the Pittsburgh district, than in any other district in the world, according to Edward W. Parker, of the United States Geological Survey. With a population of about one-ninth of that of Greater New York the consumption of coal alone in Pittsburgh is nearly equal to that of the much larger city. Greater New York consumed in 1911 approximately 19,000,000 short tons and Pittsburgh used about 16,500,000 short tons. But Pittsburgh consumes several million tons of coke and considerable quantities of natural gas, which added to the coal consumption, gives that city a good lead over New York as a burner of fuel.—"Wood Craft."

Heat Balance in Steam Boilers

By Lionel S. Marks

SYNOPSIS—Obtaining the heat balance of a furnace and boiler is a process of accounting for all the heat that would have been generated by the fuel if combustion had been perfect. This article develops a comparatively simple method of calculating it from the results of a complete test.

With a perfect furnace and boiler all the heat of perfect combustion of the fuel would be utilized in raising the temperature of the feed water and in evaporating it. In the best actual plants, the efficiency is from 75 to 80 per cent.; that is, from 75 to 80 per cent. of the heat of perfect combustion actually goes to the feed water. With the average plant, about 60 per cent. of the heat is utilized, while in poor plants the efficiency is still lower. When the efficiency of the plant is very low it is generally possible to ascertain the cause of its poor performance by inspection. With plants of higher efficiency it is not so easy and it becomes necessary to have recourse to flue-gas analyses and other observations. If it is desired to find out exactly what has become of the heat which should have been generated by the fuel and have gone into the feed water; that is, if it is desired to obtain the "heat balance" of the furnace and boiler, a complete test is necessary. The object of this article is to present a comparatively simple method of calculating the heat balance of a boiler from the results of such a test.

A boiler test which aims at a reasonable degree of completeness will generally include the following among the observations:

The weight of water evaporated; the temperature of the feed water, and the pressure and quality (or superheat) of the steam.

The temperature, pressure and humidity of the air, and the temperature and composition of the flue gases. The weight of coal burned; its proximate analysis and heat of combustion.

The weight and composition (or heat of combustion) of the refuse in the ashpit.

From these observations, it is possible to determine in detail what has become of the heat of combustion of the fuel. It has generally been considered necessary to add to the above observations the ultimate analysis of the coal, an analysis which must be carried out by a chemist and which is tedious and expensive. As will be shown later, it is generally possible to obtain the heat balance with an accuracy which is within the attainable degree of accuracy of a boiler test itself, without having recourse to the ultimate analysis.

The complete heat balance of a furnace and boiler takes into account five principal dispositions of the heat of perfect combustion of the fuel. They are as follows:

1. The heat utilized in raising the temperature of the feed water and in evaporating it.

2. The heat not developed as a result of incomplete combustion. This heat divides itself into three parts:

(a) The heat of combustion of the carbon and other combustible matter which has fallen into the ashpit and which is carried away with the ashes.

(b) The heat of combustion of any CO which may be going up the chimney.

(c) The heat of combustion of any hydrocarbons which may be escaping unburned with the chimney gases.

3. The heat being lost up the chimney as sensible heat of the dry chimney gases.

4. The heat being lost up the chimney in water vapor which accompanies the dry chimney gases. This water vapor comes from three separate sources:

(a) That which results from the combustion of hydrogen in the coal.

(b) That which comes to the furnace as moisture in the coal.

(c) That which arrives in the furnace as humidity in the air.

5. The heat lost by radiation and conduction, or heat which is otherwise unaccounted for.

The problem of determining the heat balance of a boiler resolves itself into the problem of finding the values of the quantities 1, 2, 3 and 4. The radiation and conduction must be determined by heat balance; it is the quantity remaining unaccounted for after all the other quantities have been determined.

The methods of determining these separate quantities are given below:

1. *Heat given to the feed water.* This quantity is readily determined from a knowledge of the weight of water evaporated per pound of coal, the temperature of the feed water, and the pressure and quality (or superheat) of the steam. When expressed as a percentage of the total heat of perfect combustion of the fuel burned, it measures the efficiency of the boiler plant. Its value in ordinary practice varies from 60 to about 75 per cent.

2. *Heat lost by incomplete combustion.* The object of a furnace is to burn the coal as completely as possible with the smallest possible air supply. A perfect furnace would lose no combustible matter through the grate bars into the ashpit; would convert all the carbon into carbon dioxide; would give off no unburned hydrocarbons; and would have no air of dilution; that is, would send no unused oxygen up the chimney. This perfect furnace has not yet been realized, nor is it likely to be closely approximated to with solid fuels. With liquid fuels, however, the losses from incomplete combustion and from the admission of excess air can be reduced to a very small quantity.

(a) *The heat lost with combustible falling into the ashpit.*

To determine how much heat of combustion is lost with the refuse in the ashpit, it is necessary to know the weight of the refuse and its composition, or its heat of combustion. There are, in general, three ways of determining these quantities:

(1) An inspection of the heap of refuse at the conclusion of the test may indicate to a trained observer the approximate composition of the refuse. This method is not satisfactory by itself. The refuse is generally wet when its weight is determined and the estimate of combustible must be preceded by an estimate of the amount

of moisture. In those cases where all the combustible matter which has fallen into the ashpit is well coked, it may not be very difficult to estimate the percentage by weight of combustible in the dry refuse, and since the combustible in that case will be carbon it is possible to obtain the heat that would be developed by the combustion of the refuse.

A number of modern furnaces separate the green coal which sifts through the grates from the coked fuel which falls through with the ash, and in such furnaces an estimate of the combustible in the refuse may be possible. In those cases where the siftings of green coal and of coked fuels fall into the same place and are mingled together, such an estimate becomes too uncertain.

(2) The amount of combustible in the refuse can also be obtained from the total weight of coal that has been burned and the percentage of ash which the proximate analysis of the coal shows it to contain. From these quantities, it is easy to calculate the total true ash, and if this is subtracted from the dry refuse in the ashpit, we get the total combustible matter, but we do not get any light at all on the composition of this combustible matter. depends entirely upon the accuracy with which the sample burned represents the average heat of combustion of the refuse pile.

The heat of combustion of the fuel in the refuse is seldom more than 3 to 5 per cent. of the heat of combustion of the fuel fired in well operated plants. In view of the fact that it is not possible in a boiler test to obtain an accuracy greater than 1 per cent., and generally not greater than 2 per cent., it is not important that the heat of combustion of the fuel in the refuse should be determined with very great accuracy. If an error of 10 per cent. is made in the estimate, either of the amount of combustible in the refuse or in its heat of combustion, it will make an error which generally would not be more than $\frac{3}{10}$ of 1 per cent. in the heat balance of the boiler. In determining the heat balance of a boiler, the maximum error is likely to occur in this item.

2 (b). The heat lost by the combustion of some of the carbon to CO instead of to CO_2, is readily determinable from the flue-gas analysis. Each pound of carbon burned to CO_2 gives up 14,500 B.t.u. Each pound of carbon burned to CO gives up only 4450 B.t.u. Consequent-

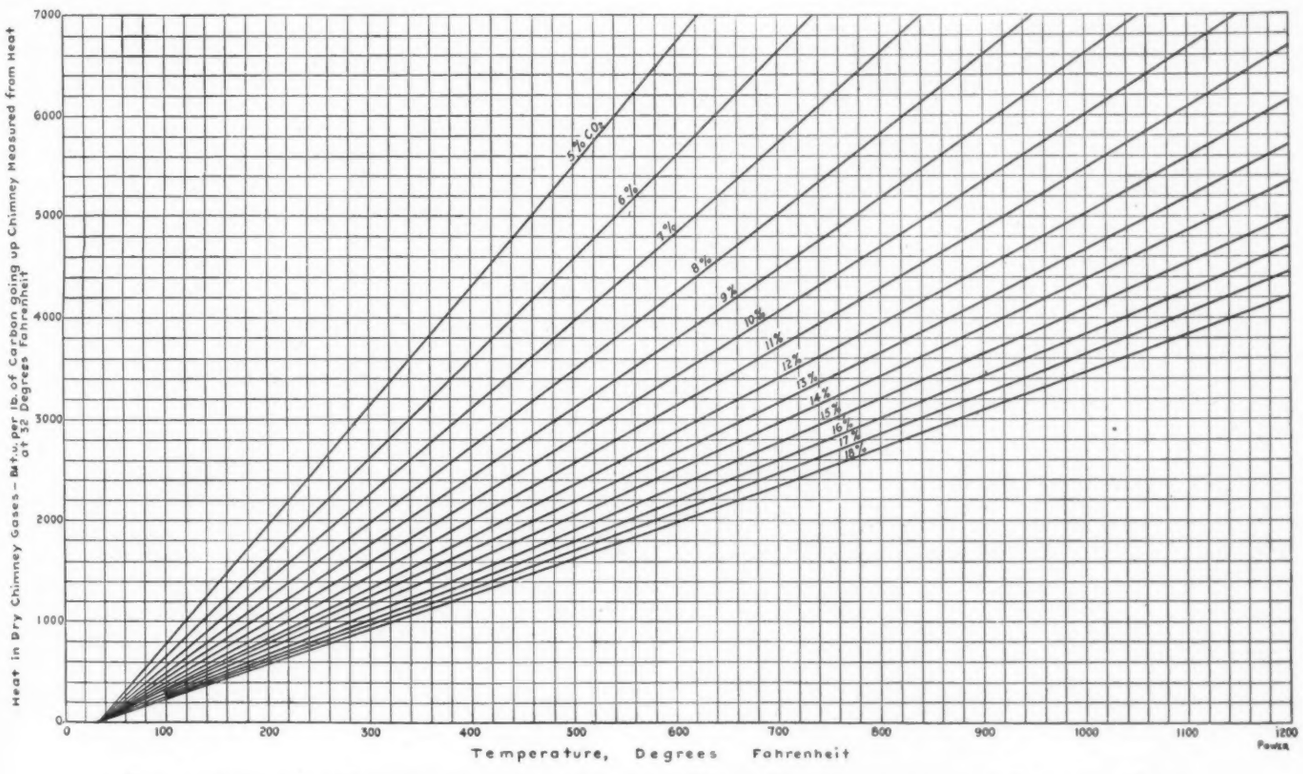


FIG. 1. CHART FOR DETERMINING THE AMOUNT OF HEAT ESCAPING WITH THE CHIMNEY GASES

The use of the second method to check the first method, has been found by the writer to work satisfactorily in those cases in which the refuse contains only coked fuel. In other cases, resort must be had to the next method.

(3) The heat of combustion of the refuse may be determined by the actual combustion of a fair sample of the refuse. This method does not give entirely satisfactory results in consequence of the great difficulty of getting a fair sample. The refuse generally contains large clinkers and it is often impracticable to break up all the clinkers in order to get a fairly homogeneous pile from which to begin to select a sample. The accuracy of this method

ly, for each pound of carbon burned to CO there is a loss of 10,050 B.t.u. If there is any CO present its amount will be determined by the flue-gas analysis. The weight of carbon in a cubic foot of CO_2 is the same as the weight of carbon in a cubic foot of CO at the same pressure and temperature. Consequently, the weight of carbon burned to CO has the same ratio to the weight burned to CO_2 as the volumes of the two gases. If x = the percentage of the total carbon burned to CO_2, and y the percentage burned to CO, then $x + y$ is the total carbon burned and

$$\frac{y}{x + y}$$

is the fraction burned to carbon monoxide. Consequently,

$$10{,}050 \times \frac{y}{x+y}$$

is the heat of combustion lost through the burning of carbon to carbon monoxide per pound of carbon going up the chimney. This can be expressed in B.t.u. per pound of coal fired when the analysis of the coal, and the percentage of the total carbon falling through into the ashpit are known.

With good operation of the furnace there should not be more than a trace of CO except in those cases where the furnace is being forced very much beyond its proper capacity. If the CO present exceeds 1 or 2 per cent., it may safely be inferred that the incomplete combustion which this indicates extends also to the hydrocarbons.

2 (c) Heat lost with hydrocarbons escaping unburned up the chimney.

Whenever visible smoke escapes from a chimney it is probable that some hydrocarbons are escaping unburned. The denser the smoke, other things being equal, the greater is the probability of the loss of unburned hydrocarbons. The ordinary flue-gas analysis does not give any

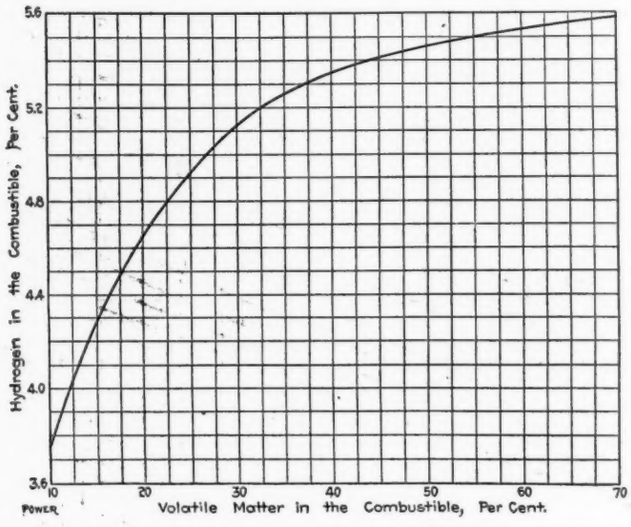


FIG. 2. CHART FOR DETERMINING HYDROGEN FROM THE PERCENTAGE OF VOLATILE MATTER

definite indication of the presence of these gases. Under normal conditions of operation of steam plants, with not more than a trace of CO and with little or no visible smoke, one may feel pretty sure that there is no appreciable loss of hydrocarbons up the chimney. In other cases, there may be such a loss, but there is no available means of determining its amount. Special tests and also the heat balances of many boilers indicate that this loss is normally quite negligible.

3. *Heat lost with the dry chimney gases.* The gases escaping up the chimney are carbon-dioxide, oxygen, carbon-monoxide and nitrogen. These are usually collected over water and measured over water They are, consequently, saturated with water vapor and their analysis shows nothing at all about the content of water vapor of the gases as they are going up the chimney. The heat carried away by these gases is the heat that would be given up by cooling the dry gases from the chimney temperature to the temperature of the air in the boiler room. The amount of this heat for each of the constituents is equal to

$$wC_p\,(T_c - T_a)$$

where

w = Weight of each of these constituents per pound of carbon going up the chimney;

C_p = Mean specific heat at constant pressure from the boiler-room temperature up to the temperature of the chimney;

T_c = Temperature of the chimney;

T_a = Temperature of the entering air.

The specific heat of the gases going up the chimney varies with the temperature, and, according to the best authorities, the mean specific heat from 32 deg. to any temperature t deg., is as follows:

For

Oxygen	$C_p = 0.2125 + 0.00001\ (t - 32)$
Nitrogen	$= 0.243 + 0.000012\ (t - 32)$
Carbon monoxide	$= 0.243 + 0.000012\ (t - 32)$
Carbon dioxide	$= 0.201 + 0.00041\ (t - 32) - 0.000000055\ (t - 32)^2$

To facilitate the calculation of the total heat escaping up the chimney, the chart, Fig. 1, has been prepared. In this chart the horizontal scale gives the temperature of the gas; the vertical scale gives the sensible heat being carried away by the gases in B.t.u. per pound of carbon going up the chimney. The lines are labeled according to the percentage of CO_2 which analysis shows to be present. These curves are calculated on the assumption that the gas contains (in addition to the percentage of carbon dioxide marked on the curves) 80 per cent. of nitrogen, and that the rest of the gas is oxygen. In those cases where some CO is present, the correction is quite negligible if the CO is reckoned as CO_2. For example, with 15 per cent. of CO_2 and 2 per cent. of CO, and with a chimney temperature of 632 deg. F., the heat of the gases is 2183 B.t.u. If it is assumed, for the purposes of this calculation, that the CO acts as CO_2, we have 17 per cent. of CO_2, the sensible heat of which is 2200 B.t.u.; the difference is only 17 B.t.u. In using Fig. 1 the heat contained in the gases at boiler-room temperature must be subtracted from the heat at chimney temperature in order to find the heat carried away by the dry gases.

The amount of heat escaping with the dry gases up the chimney can readily be expressed, as a percentage of the total heat of perfect combustion when the relation of the carbon escaping up the chimney to the weight of fuel has been determined from the proximate analysis of the fuel, and the correction has been made for the carbon falling through into the ashpit.

4. The heat escaping up the chimney with the water vapor is equal to the total heat of this vapor minus the heat which it has when at the temperature of the room. It is necessary, however, to decide whether the vapor must be considered in the vapor or the liquid form at this lower temperature. This question is decided separately under each of the following headings:

(a) The moisture resulting from the combustion of hydrogen in the coal.

To determine the amount of this water vapor, it is necessary to know how much hydrogen is present in the dry coal. The usual way of determining this quantity has been to make the so called ultimate analysis of the coal, which determines not only the hydrogen but also the total carbon, oxygen, nitrogen and sulphur. As already pointed

out, this determination is tedious and expensive. It is possible to determine the hydrogen from the proximate analysis with a degree of accuracy which is sufficient for all ordinary purposes. As was pointed out by the writer in an article in POWER, Vol. 29, page 928, December, 1908, there is a definite relation between the hydrogen content of the combustible matter of American coals, and the total amount of the volatile matter expressed as a percentage of the total combustible of the coal. This relationship is shown on the accompanying curve, Fig. 2.

Professor Diederichs has deduced an equation for this curve of the form

$$H = v\left(\frac{7.35}{v+10} - 0.013\right)$$

where

H = Percentage weight of hydrogen in the combustible;

v = Percentage weight of volatile matter in the combustible.

By the use of either the curve or the equation, it is possible to determine the hydrogen content of a coal with an accuracy of about $\frac{2}{10}$ of 1 per cent.

The carbon in the volatile matter of the coal is determinable with less accuracy by the curve shown in Fig. 3. The error in this case may be as much as 2 per cent. for the more common fuels; while for lignites and other special fuels, it may be even greater. The total carbon in coal is the sum of the fixed carbon and of the carbon in the volatile matter. If this latter is determined by the use of Fig. 3, the total carbon per pound of coal can be readily determined.

Assuming that it is sufficiently accurate to take the hydrogen and carbon content of the volatile combustible matter of a coal from the two curves given, it becomes possible to get the practical equivalent of that part of the ultimate analysis of the coal which is required for the calculation of a heat balance.

When hydrogen burns to H_2O, its weight increases ninefold; consequently, the weight of water vapor resulting from the combustion of hydrogen is immediately determinable. The heat carried up the chimney by this moisture is given by the equation

$$Q = w(H - h)$$

where

w = Weight of the H_2O formed per pound of coal burned;

H = Total heat per pound of steam at chimney temperature;

h = Heat of one pound of water at boiler-room temperature.

The total heat H of water vapor at ordinary chimney temperatures and at the pressures commonly occuring in the chimney, is practically independent of the pressure, and is given in Fig. 4. The heat of one pound of water h at the temperature of the boiler-room may be taken as the boiler-room temperature minus 32.

(b) Moisture in the coal.

The proximate analysis of the coal gives the total weight of moisture content in the coal. The heat which it carries up the chimney is calculated as in the previous paragraph.

(c) Moisture entering with the air.

Air under ordinary atmospheric conditions, contains some water vapor. The weight of this vapor cannot exceed the weight of an equal volume of dry and saturated steam at the same temperature. The accompanying curves, Fig. 5, show approximately the ratio of the heat carried up the chimney by the dry chimney gases to the heat being carried away by the water vapor which entered with the air. As this latter quantity is always a small fraction of the heat of the dry chimney gases, it is not necessary to calculate its amount exactly. The curves have been calculated on the assumptions that the specific heat of water vapor is twice that of the chimney gases, and that the chimney gases have the physical properties of air. By reference to the curves, it will be seen that with air at 80 deg. F. and humidity 80 per cent., the heat being carried up the chimney with the moisture which entered with the air, is $^1/_{34}$ or 3 per cent. of the heat of the dry chimney gases. The chimney gases seldom carry off more than 15 per cent. of the heat of perfect combustion

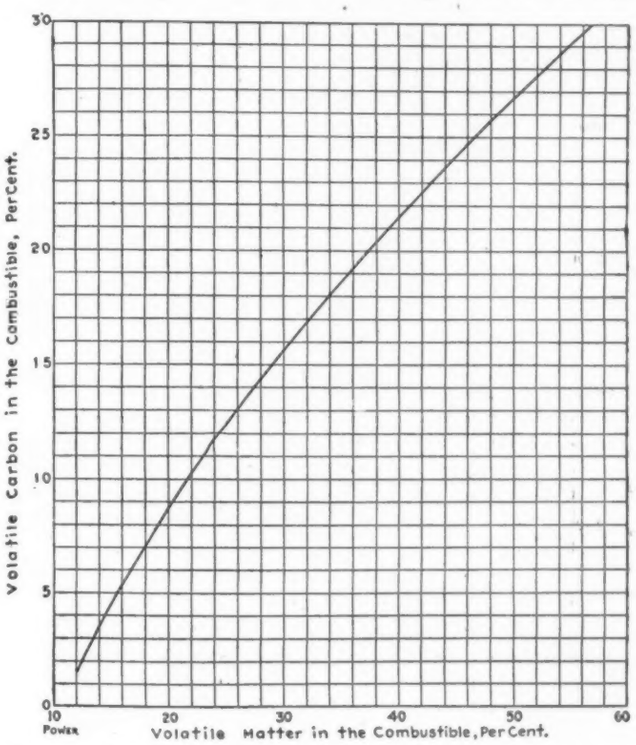


FIG. 3. CHART FOR DETERMINING THE CARBON IN THE VOLATILE MATTER

of the coal. Assuming this amount, the total heat in the water vapor under the suggested conditions is

$$^1/_{34} \times 15 = 0.5 \text{ per cent.}$$

approximately of the heat of perfect combustion of the coal. This quantity is seldom exceeded. The loss is commonly not more than 0.2 to 0.3 per cent.

5. Any heat not accounted for under the preceding headings is assumed to be lost by radiation and conduction. This unaccounted for quantity is seldom less than 2 per cent. of the heat of perfect combustion and may be as much as 4 or 5 per cent. Any test in which this quantity falls outside the limits of 2 and 5 per cent. should be looked upon with suspicion until some explanation has been found. The writer has come across a number of tests showing high efficiencies in which this unaccounted for quantity has a negative value. Such tests must be rejected as worthless.

As an example of the determination of the heat balance of a boiler plant, we may assume the following data from a boiler test:

Weight of feed water evaporated per pound of coal fired	9 lb.
Temperature of the feed water	90 deg. F.
Pressure of the steam, absolute	160 lb. per sq in.
Superheat of the steam	60 deg. F
Temperature of the air entering the boiler room	70 deg. F.
Humidity of the air entering the boiler room	60 per cent.
Temperature of the flue gases	550 deg. F.
CO_2 in the flue gases by volume	13 per cent.
CO in the flue gases by volume	1 per cent.
Heat of combustion of the coal as fired	14,000 B.t.u.
Proximate analysis of the coal:	
Moisture	4 per cent.
Volatile matter	25 per cent.
Fixed carbon	62 per cent.
Ash	8 per cent.
Sulphur	1 per cent.
Weight of refuse in the ashpit per pound of coal fired	0.131 lb.
Estimated moisture in the refuse by weight	20 per cent.
Estimated carbon in the dry refuse by weight	30 per cent.

The proximate analysis of the coal shows it to contain 12 per cent. of noncombustible matter (moisture and ash), and 88 per cent. of combustible. The percentage composition of the combustible matter is, consequently:

Volatile matter $25 \times \frac{100}{88} = 28.3$ per cent.
Fixed carbon $62 \times \frac{100}{88} = 70.5$ per cent.
Sulphur $1 \times \frac{100}{88} = 1.1$ per cent.

With a coal whose combustible matter has the above composition we see from Figs. 2 and 3 that the volatile hydrogen is 5.1 per cent., and the volatile carbon is 14.5 per cent. of the combustible matter.

The total carbon is $14.5 + 70.5 = 85$ per cent. of the combustible, or

$$85 \times \frac{88}{100} = 74.8 \textit{ per cent.}$$

of the coal is fired.

From the above data we determine the heat balance as follows:

1. The heat given to one pound of water is found from the steam tables to be

$$1230 - 58 = 1172 \text{ B.t.u.}$$

Consequently the heat absorbed by the feed water per pound of coal fired is

$$9 \times 1172 = 10{,}548 \text{ B.t.u.}$$

The efficiency of the boiler is

$$\frac{10{,}548}{14{,}000} = 75.3 \textit{ per cent.}$$

2a. The refuse in the ashpit is 0.131 lb. per lb. of coal fired. An estimate of 20 per cent. of moisture gives 0.105 lb. of dry refuse, and the further estimate of 30 per cent. of carbon in the dry refuse gives 0.031 lb. of carbon, and 0.074 lb. of ash per lb. of coal fired.

The proximate analysis of the coal shows that the ash should be 0.08 lb. This is a fairly good check. Assuming that the amount of ash given by the proximate analysis is correct, we find $0.105 - 0.08 = 0.025$ lb. of carbon falling unburned through the grate bars per pound of coal fired. The heat lost by this incomplete combustion is $0.025 \times 14{,}500 = 362$ B.t.u., or

$$\frac{362}{14{,}000} = 2.6 \textit{ per cent.}$$

of the heat of perfect combustion of the coal.

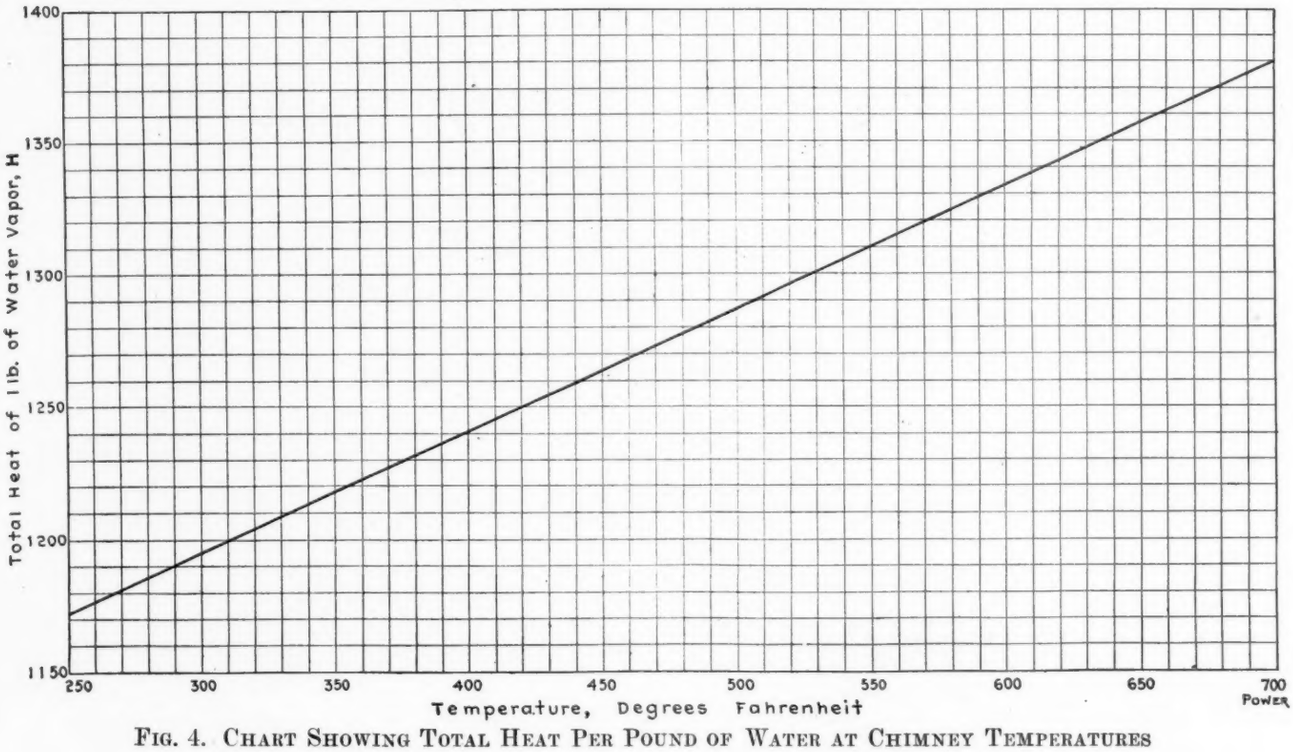


FIG. 4. CHART SHOWING TOTAL HEAT PER POUND OF WATER AT CHIMNEY TEMPERATURES

2b. The flue gases contain 13 per cent. of CO_2 and 1 per cent. of CO. The carbon going up the chimney as CO is, consequently, $\frac{1}{14}$ of the total carbon going up the chimney.

The total carbon contained in one pound of coal is 0.748 lb. and of this 0.025 lb. falls into the ashpit. The carbon going up the chimney is, consequently, $0.748 - 0.025 = 0.723$ lb. per lb. of coal fired.

The carbon burned to CO is then $\frac{1}{14} \times 0.723 = 0.0516$ lb., and the heat lost thereby is $0.0516 \times 10{,}050 = 519$ B.t.u., or,

$$\frac{519}{14{,}000} = 3.7 \textit{ per cent.}$$

of the heat of perfect combustion of the coal.

3. The heat lost with the dry chimney gases is ob-

tained from Fig. 1. With 14 per cent. of CO_2 and CO at 550 deg. F. the sensible heat of the dry gases is 2280 B.t.u. per lb. of carbon going up the chimney. This is measured above 32 deg. F. The heat of the gases at 70 deg. F. (the boiler room temperature) is seen from the same figure to be 160 B.t.u. Consequently the loss up the chimney is 2280 — 160 = 2120 B.t.u. This corresponds to 2120 × 0.723 = 1533 B.t.u., per pound of coal fired, or

$$\frac{1533}{14{,}000} = 11.0 \textit{ per cent.}$$

of the heat of perfect combustion of the coal.

4a. The moisture resulting from the combustion of the hydrogen in the coal is 9 × 0.051 lb. per lb. of combustible, or $9 \times 0.051 \times {}^{88}/_{100} = 0.404$ lb. per lb. of coal fired. The heat which it carries with it is seen by reference to Fig. 4, to be 0.404 (1310 — 58) = 505.8 B.t.u., or

$$\frac{505.8}{14{,}000} = 3.6 \textit{ per cent.}$$

of the heat of perfect combustion of the coal.

4b. The moisture in the coal is 0.04 lb. per lb. of coal. The heat which it takes up the chimney is 0.04 (1310 — 58) = 50.1 B.t.u., or, 0.4 per cent., approximately, of the heat of perfect combustion of the coal.

4c. With air at 70 deg. F., and humidity 60 per cent., the vapor entering with the air is seen from Fig. 5 to carry up the chimney $^1/_{62}$ of the heat of the dry chimney gases. This heat has been seen to be 11 per cent. of the heat of perfect combustion of the coal. The loss due to the moisture in the air is consequently

$$\frac{11.0}{62} = 0.2 \textit{ per cent.}$$

approximately.

5. The heat lost by radiation and conduction, or otherwise unaccounted for, is obtained by balance. The disposition of the heat is seen to be as follows:

Heat given to the feed water	75.3 per cent.
Loss by unburned carbon in ashpit	2.6 per cent.
Loss by CO up the chimney	3.7 per cent.
Loss with dry chimney gases	11.0 per cent.
Loss with moisture from hydrogen in the coal	3.6 per cent.
Loss with moisture in the coal	0.4 per cent.
Loss with moisture in the air	0.2 per cent.
Radiation, conduction, etc.	3.2 per cent.
	100.0 per cent.

As was pointed out earlier, the use of the curve in Fig. 3 for determining the carbon in the volatile matter of a coal, may give results which are in error by 2 per cent. or more. To ascertain the influence of such an error on the heat balance the preceding calculations have been repeated, taking the volatile carbon as 16.5 per cent. instead of 14.5 per cent. shown by the curve. The only changes which this produces is to increase item 2 (b) by 0.1 per cent., item 3 by 0.3 per cent., and consequently to reduce item 5 by 0.4 per cent. These changes are unimportant and justify the use of Fig. 3.

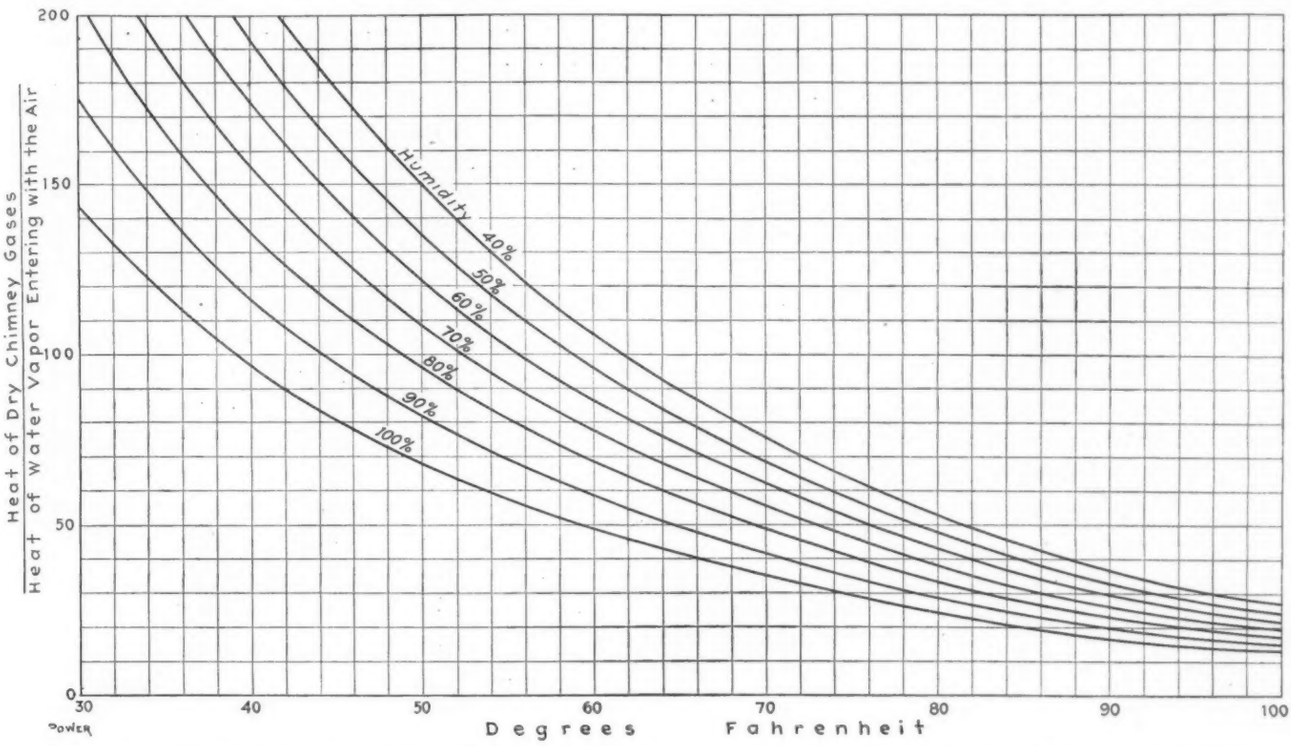


FIG. 5. CHART SHOWING AMOUNT OF HEAT CARRIED UP THE CHIMNEY BY THE WATER VAPOR OF THE AIR

Double Acting Hacksaw Blade

A new design of hacksaw blade is being placed on the market by Alexander Reitlinger, 201 William St., New York City. It differs from other saw blades in that each set of four teeth pitch in opposite directions with a straight tooth between each set of slanting teeth. Claims made by the manufacturer for these saws are that they will cut faster and cleaner than when made with the teeth all in one direction, and that they will cut iron pipe without breaking the teeth. When used in a power-driven frame the blade must be used in one which does not lift on the back stroke, in order that it may cut on both strokes.

ELECTRICAL DEPARTMENT

The Storage Battery—I

By John A. Randolph

There are several methods by which electrical energy can be generated for practical use, the principal ones of which are: the electrostatic, the electrodynamic and the electrochemical. The first finds its chief use in the laboratory while the latter two are universally employed for commercial purposes. The electrochemical method is confined to the battery, the energy being produced by the action of a chemical compound upon two plates or electrodes, one or both of which is made of metal.

There are two kinds of battery, the primary type and the storage or accumulator class. Under the first classification belong all batteries designed either to be replenished after discharge by the addition of fresh plates, mixtures or solutions or to be completely replaced by a new outfit. This type is used on circuits employing small intermittent currents. The batteries of the storage class are so composed that upon discharge they can be readily replenished electrolytically. In other words, they are recharged as the resultant effect of a current passed through them in a direction opposite to that of discharge. The storage battery is always used where it can be quickly and conveniently connected for recharging to another source. The primary type is used on circuits which would not justify the more expensive installation of a battery of the other class.

The storage battery is composed of three fundamental working elements, namely: the positive plate, the negative plate and the electrolyte. There are several processes used in the manufacture of the plates, but the one most generally employed consists in making the positive elements of lead peroxide (PbO_2) and the negative of sponge lead (Pb). The electrolyte consists of sulphuric acid (H_2SO_4) diluted with water (H_2O). The active materials are held in their respective positions by lead grids.

There are various theories in regard to the chemical reactions which take place in a storage cell, but the one most generally accepted is that the passage of the current upon discharge causes the acid to react upon the active materials of the plates forming in their places lead sulphate ($PbSO_4$) the reaction being accompanied by a reduction of part of the acid and the formation of water in its place. This is the cause of the decrease in the density of the electrolyte observed upon discharge. The chemical formula expressing the reaction at the positive plate upon discharge is

Lead Peroxide		Sulphuric Acid		Lead Sulphate		Water		Oxygen
PbO_2	+	H_2SO_4	=	$PbSO_4$	+	H_2O	+	O

That of the negative plate is

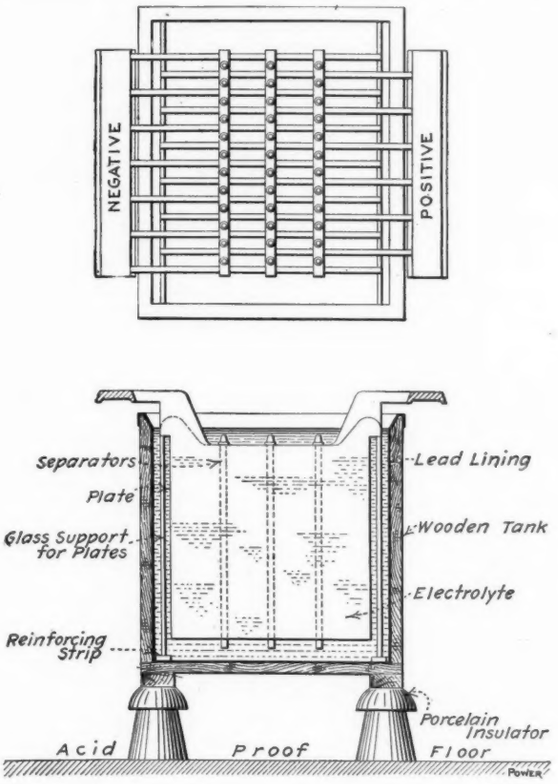
Sponge Lead		Sulphuric Acid		Lead Sulphate		Hydrogen
Pb	+	H_2SO_4	=	$PbSO_4$	+	H_2

Combining these two equations, we have

$$PbO_2 + Pb + 2\,H_2SO_4 = 2\,PbSO_4 + 2\,H_2O$$

The latter equation is known as the fundamental equation of the storage battery.

It is evident, from the foregoing analysis, that if the discharge were continued indefinitely, the active materials of the plates would practically all be changed to lead sulphate. This would ruin the battery because of the chemical nature of the sulphate. This compound offers a very high resistance to the electric current and, when not mixed with another substance of a conducting nature, it is extremely difficult to decompose it electrolytically. It would, therefore, be impossible to recharge the battery if the sulphating were continued too long. If the discharge is stopped while other materials remain mixed with the sulphate in sufficient quantities to insure a ready passage of the charging current, the sulphate can be easily broken up and the battery recharged without difficulty.



Plan and Section through Cell

Upon charging, the current is passed through the battery in the direction opposite to that of discharge, with the result that the reactions expressed in the foregoing equations are reversed. The lead sulphate is reduced, the active materials—lead peroxide and sponge lead—are restored to their respective plates and the acid taken from the electrolyte on discharge returns to it, the water

previously formed disappearing. This replenishment of the electrolyte causes the rise in density observed upon charging. If the equations of discharge are read from right to left, they will express in each case the reaction upon charging. The combined or fundamental equation will now read

$$2PbSO_4 + 2H_2O = PbO_2 + Pb + 2H_2SO_4$$

Capacity

The capacity of a battery is rated according to the current it can deliver for a given duration of time. It is expressed in ampere-hours and is, therefore, the product of the rate of current flow, or amperage, and the time in hours during which this flow is maintained. For instance, an 8000-ampere-hour battery is one which can deliver a current of 1000 amperes for eight hours or a current of 2000 amperes for four hours. The rate of current flow depends upon the combined area of the positive plates exposed to the electrolyte, the area of each plate being considered as the sum of the areas of its two sides. The capacity, on the other hand, is dependent not only upon the size and construction of the plates, but upon the quantity, quality and density of the electrolyte and the nature of the active materials employed. To secure the most economical results, the active material should be so disposed as to allow the ready circulation of the acid through all its parts. For this reason, it should be porous and offer a short path for the electrolyte from one side of the plate to the other. The holding grids should be so constructed that they will make good electrical contact at all times with the active material. With the formation of sulphate at discharge, the active material expands, while upon charging, it contracts to its former size. The grid should be able to adapt itself to these changes. If it does not, the active material, as it alternately increases and decreases in volume, will be loosened from the grid, causing poor electrical contact and a gradual breaking apart of the paste, which will cause the latter to fall to the bottom of the cell and become useless. Moveover, unless the grid is designed for proper adjustment to the changes in the paste, there will be a tendency for the grid to warp or buckle which will further enhance the efficiency and life of the battery.

Voltage

When the battery is first placed on charge, the voltage will rise rapidly for a short time and then assume a slower and more gradual increase for the remainder of the period except near the end, when it will again rise rapidly to a maximum. This action will be reversed in a similar manner upon discharge. These conditions, however, are dependent upon the disposition of the active materials, the temperature and the density of the electrolyte. Unless the paste is so arranged that the acid can percolate through it freely, the reactions will be retarded, causing a corresponding variation of voltage upon discharge and hindering the normal rise upon charge. Moreover, the activity of the electrolyte depends upon its density and is also affected to a certain extent by the temperature.

Construction and Installation

As usually constructed, the plates are so spaced that those of one polarity fit alternately into the spaces between those of the opposite sign, sufficient clearance being maintained to prevent short-circuit and to allow ample space for the electrolyte. All the plates of like polarity are joined together outside the cell, the positive connection being at one side and the negative at the other. The plates are held apart by separators of hard rubber, wood or glass. The electrodes and electrolyte are contained in a jar or tank made generally of glass, hard rubber, or wood lined with lead. Glass is used on small stationary batteries, while the lead-lined wooden tank is employed on the larger sizes. Hard rubber finds its principal application on batteries used for traction work and portable purposes. When the containers are of glass, the plates are supported directly from the sides of the jar, but in the lead-lined tank, they rest upon two independent glass supports, one on either side of the tank. The jars or tanks are thoroughly insulated from the earth and from one another by supports which usually consist, in the larger sizes, of a combination of triple petticoat porcelain insulators and wooden frames or blocks. The construction of a typical large-sized battery cell is shown in the illustration.

The floor of the battery room should be of wood, brick, vitrified tile or asphalt but never of cement or a material affected by acid fumes or leakage. The wooden portion of the tanks and all materials in the room susceptible to acid corrosion should be protected by acid-proof paint or by a covering that will likewise resist corrosion. Good ventilation should be maintained to prevent the accumulation of fumes.

Lessons of a Power Plant Accident

By H. S. Knowlton

To the operating engineer the detailed study of accidents occurring with electrical or other machinery in a power plant is generally suggestive. There is no question that the careful investigation of service troubles is one of the most profitable practices in which an engineer can engage, but in many cases where breakdowns have happened, there has been little opportunity for thorough analysis of conditions at the time by men experienced in the design and ultilization of equipment. The first duty of the engineer is obviously to resume service; later, if time permits, he can make a careful report of the circumstances, and it often happens that such reports are more or less fragmentary.

In the following are given the results of a careful study of an electrical accident in a steam turbine station made by an experienced engineer who was on the way to visit the installation when the accident occurred, and who arrived at the plant within a few minutes after the breakdown. He was not employed by the operating company, and was consequently, at the latter's suggestion, free to investigate the situation without restrictions. The investigation and report indicated the importance of better protection of exciter service and the independent operation of electrical auxiliaries of various kinds, with more regard to the evils of energy reversals between the power plant in trouble and substations connected with it.

The shutdown occurred in a large generating plant in which the relays, speed-limit devices and turbine-speed control as well as the auxiliaries were supplied entirely from the exciter system. A piece of casting of a vertical

turbo-generator became detached and dropped into the revolving member which forced it against the field windings, destroying some and grounding the field circuit. By this accident the entire system of auxiliaries was rendered inoperative. One turbine ran away, and the high voltage generated on part of the system produced disastrous results.

In the retail business district supplied by the company there was a large storage battery floating on the system. This was connected through rotary converters to the generating station and as the direct-current automatic circuit-breakers between the battery and the converters failed to act, the latter were run inverted, thus supplying power to the generating plant and doing considerable damage.

A study of the accident immediately after its occurrence, indicated that the use of an independent source of power for the circuit-breakers alone would not have been sufficient to prevent trouble, because other auxiliaries were involved at the same time and a complicated situation arose. Some of the damage would have been done regardless of the circuit-breakers, although this was, in a great measure, communicated to other apparatus by the failure of the local circuit supplying the auxiliaries.

It appeared that if the switchboard operator in the plant had been able to control the oil circuit-breakers, which were connected in the main circuits between the generators and the busbars and between the latter and the feeders supplying the substations, he might have been able to confine the trouble to the machine first affected.

All the oil circuit-breakers were operated from a gallery overlooking the turbo-generators. If these could have been controlled by a single master switch opening them in an instant, more of the damage probably could have been prevented than had the operator been able to open the circuits by the individual controllers which were in service at the time of the accident. It would have been impossible by the opening or closing of oil circuit-breakers to have saved the first machine, which had its field short-circuited and grounded, but the second might have been protected in this way.

An analysis of operating conditions and the plant equipment indicated that much of the damage was due to the fact that the various auxiliaries which should have come into play were not supplied from a local circuit deriving its power from an absolutely independent source, such as a storage battery. The independent supply should have applied to the turbine governors, which were of the electrically operated type. It also appeared advisable to install automatic relays in all of the lines which supplied power to other systems from the busbars, capable of being set to trip the oil circuit-breakers in case of an excessive overload. In addition proper reverse-current relays should have been supplied in the various substations, which would have prevented the reversal of the energy supply in these circuits supplying power to feed the short-circuits and grounds which existed in the generators. It also seemed essential that speed-limit devices and perhaps reverse-current relays should have been supplied for the rotary converters, so that they would have been disconnected from the whole system when the energy began to flow into the converters from the substation batteries..

It was believed at the time of the accident that the machine not at first damaged supplied power to the short circuit in the armature of the injured generator or to the ground existing in its windings, thus making the damage more serious. At the same time power from the busbars feeding into the armature of the former caused a bad burnout in the armature after the insulation was punctured by the rising voltage. Therefore it appeared that relays operating from series transformers connected on the main leads of the generators would have been a valuable feature, for being supplied from an independent source, and set to operate when there was a reversal of energy, they would have automatically disconnected the generators from the busbars before serious damage had been done.

CORRESPONDENCE

What Reversed the Polarity?

We have two generating units, each consisting of a 26x36-in. Corliss engine driving a direct-current generator. As the load is not large only one set is used at a time.

A short time ago a sudden jar occurred which unlatched the governor. The engine immediately slowed down and would have stopped had not the engineer reset the governor and started up again. Upon going to the switchboard, however, to adjust the voltage, he found that the polarity of the generator had been reversed.

I have often known of a generator running in parallel with another being reversed but have never known this to happen to a generator running by itself. What could have caused such a thing? This unit was stopped and No. 2 started. When No. 1 was put in service again a motor generator set was used to reverse the polarity employing about 100 volts for the purpose. Since then we have had no trouble.

JOHN H. GIBBENEY.

Rowes Run, Penn.

❋

Unequal Air Gap

Last fall complaint was made about a 50-hp. two-phase motor, the owner stating it had no power. Upon investigating we found that the main bearing had worn enough to let the stator strike the frame enough to throw fire, although the coils were not damaged. We took the motor into the shop, removed the copper bars in the motor and insulated them with oiled linen. On each side of the short-circuiting rings were three small pieces of angle-iron to keep the bars from slipping endways on the rotor. These were insulated from the body of the rotor with pieces of fiber.

We then proceeded to rebabbitt the bearings, first putting the rotor in place and blocking it with thin pieces of tin so as to get the air gap equal. The motor was then placed in service and handled its load better than ever. Unless the air gap is equalized, an induction motor will lose power.

G. ANDERSON.

Cresco, Ia.

GAS POWER DEPARTMENT

Diesel Engines at English Country House

By Arthur H. Allen

Many of the ancient mansions which are scattered over the British Isles have been equipped with installations for electric lighting, and the introduction of the tungsten lamp, with its small consumption of energy, has given a great impetus to this class of work. In many cases the generating plant is driven by gasoline engines, which can be managed by the chauffeur of the establishment; but gasoline is too expensive for the larger installations, which, therefore, use oil engines, suction gas plants or, in a few cases, Diesel engines. One of the largest of these installations is that at Stoneleigh Abbey, Fig. 1, the country residence of Lord Leigh, a great part of which was erected 900 years ago, the newer portion having been added in the seventeenth century.

Fig. 1. Stoneleigh Abbey

The installation comprises about 1500 incandescent lamps and a number of motors. The generating plant consists of two Diesel engines of 50 hp. each, coupled direct to four-pole interpole dynamos. The plant is housed in one of the roomy old stables belonging to the estate, which affords ample accommodation. A 10-ton underground tank is provided outside the building for the storage of the fuel, which is Texas crude oil. The oil is pumped by hand to an overhead tank, from which it flows to the engines through filters. As the local water supply is hard, and would deposit sediment in the water jackets, the cooling water is circulated through a cooler, in which an artificial draft is maintained by a motor-driven fan, so that the same water can be used continu-

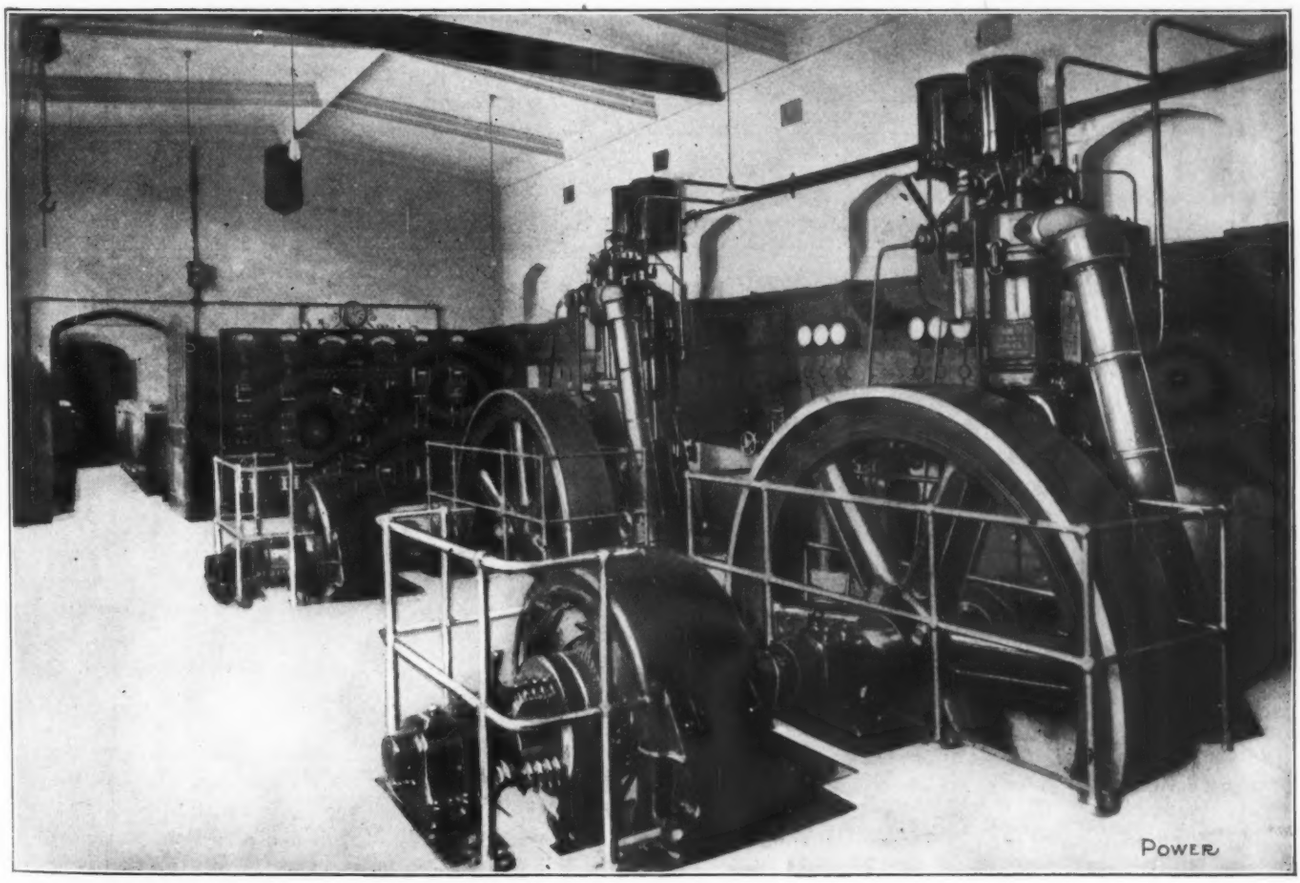


Fig. 2. Diesel Engine Units and Switchboard

ously. The exhaust from the engines is passed into a drum silencer, connected by a short pipe to a second drum, from which it finally escapes through an uptake provided with an expanding head with an inner cone, the result being that the exhaust is almost inaudible.

Fig. 2 shows the generating plant, together with the main switchboard, which provides for two feeders—one to the house and the other to the farm buildings—besides the dynamos and storage battery. The latter, which is situated in the adjoining room, is exceptionally large for a plant of this kind, having an output of 2000 amp.-hr. at the 10-hour rate and 100 volts, and is capable of supplying 900 amp. for short periods. The battery is controlled by an automatic regulator connected to the discharge switch.

The main cables are laid underground, in ducts filled up with bitumen. In the buildings the wiring is inclosed in screwed solid-drawn steel tubing, and the greatest care has been taken to avoid injury to the ancient wainscoting and other woodwork in the Abbey.

Electric motors have been freely used to drive small

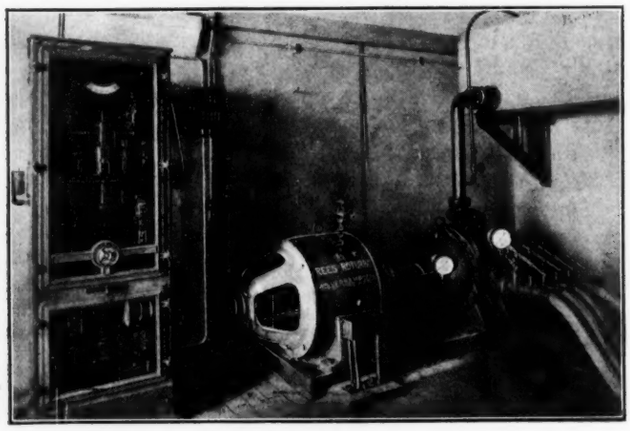


FIG. 3. FIRE PUMP AND CONTROL BOARD

domestic appliances, as well as the organ in the old chapel of the abbey. In the farm buildings, which are also lighted with electricity, motors drive the chaff-cutter and corn-crusher, as well as a large sawmill.

One of the most interesting features of the installation is the fire-pumping plant, Fig. 3. Formerly a steam engine was employed, but it took some time to get this into operation, and a motor-driven pump has now been substituted. The pump is of the Rees-Roturbo type, and is self-regulating, when driven at constant speed. The pump, which derives its supply from the river Avon, is permanently connected to the fire mains running through the abbey and on the roof of the latter, and can throw water over the top of the building; its maximum output is 400 gal. per minute at 117 lb. pressure. It is kept primed constantly by water from the domestic supply. Hydrants are fixed at various places in the building, and at each of these there is a push-button, by which the pump can be instantly started, the switch gear in the pump room being entirely automatic; the full water pressure is available in less than half a minute.

Formerly coal was used for the steam fire pump and the engine driving the sawmill, and oil for lighting; these items cost about $2500 a year, whereas the fuel oil for the Diesel egines, which has replaced them, costs only $125 a year. The installation was carried out by Percy Oliver, of the Midland Electric Light & Power Co., to whom the writer is indebted for permission to publish these particulars.

Cost of Power with Small Gas Engine Unit

BY SAMUEL B. MOORE, JR.

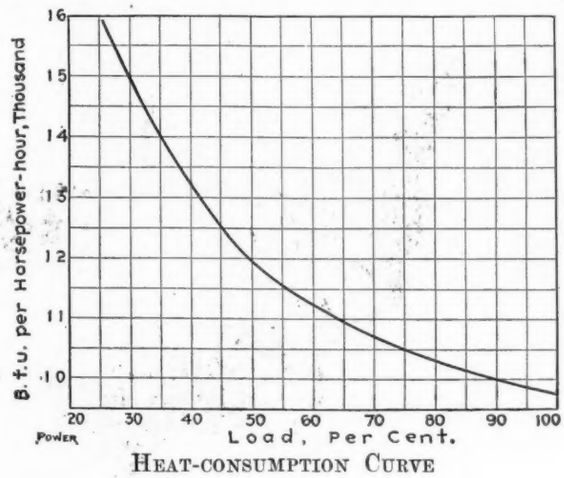
A large and growing industrial concern was recently confronted with the problem of procuring additional power for its plant. An increase of business had necessitated the operation of part of the plant by night, which meant proper lighting facilities. The only lighting means then at the command of the company was gas, but this was not adaptable to their special needs. Electric lighting was imperative; hence the question of purchasing or generating current for lighting arose.

The motive power for the plant was steam, but when the lighting question came up the boiler plant was already operating at its maximum. There were three courses possible: First, to buy current at 8c. per kw.-hr.; second, to install a new boiler (which would mean an addition to the boiler house) and a steam-driven generator, the total cost of installation approximating $4000; third, to install a generator driven by a gas engine at a cost of about $3800.

The last course was selected and the unit was installed. The engine is a three-cylinder, four-stroke-cycle, 65-hp. gas engine, direct connected to a 40-kw., 60-cycle generator, which is capable of carrying 20 per cent. overload. The ignition is of the make-and-break type, the starting current being furnished by a storage battery and the running current by a magneto belt driven from the main shaft. The system is so wired that the current from the magneto always keeps the storage battery charged.

Illuminating gas of about 560 B.t.u. net heat value is used. The engine cylinders are water cooled, and the water outlet is connected to the steam-boiler supply, so effecting economy by using the water twice and utilizing the heat.

To determine whether the engine fulfilled the capacity and regulation guarantee of the maker a series of tests was made, the results of which are given in the next table. Two-hour runs were made with one-quarter, one-half, three-quarter and full loads, all measurements of power being determined with a prony brake. As will be noted the gas consumption at all loads is good. The



HEAT-CONSUMPTION CURVE

speed varied between 281 r.p.m. with no load and 274 with full load, thus giving 2.5 per cent. regulation, which is satisfactory.

RESULTS OF TESTS:

Nominal load	¼	½	¾	full
Duration of test, hours	2	2	2	2
R.p.m.	280	280	279	274
B.t.u. per cu. ft. of gas	562.4	558.7	555	561.3
Gas consumed by engine, cu. ft.	954	1350	1865	2270
" " " per hour	477	675	933	1135
Net weight on prony brake, lbs.	67	122.5	195	259
Brake horsepower	17	31.2	49.45	64.9
Cu.ft. gas per b.hp.-hour	28.1	21.7	18.89	17.45
B.t.u. gas per b.hp.-hour	15800	12100	10484	9793
Per cent. of rated load	27	48	76	99.8
Temperature of cooling water, deg. F.	186	182	182	187

These values are perhaps more easily compared when presented graphically. The curve indicates the relation between the heat consumption per horsepower-hour and the brake horsepower.

Since installation, nearly one year ago, the plant has been in operation 216 days, with an average daily output of 207 kw.-hr. per ten-hour day, showing a fuel consumption of 6065 cu.ft. of gas per day. The average cost per kw.-hr. is 4.59c. and is arrived at from the following figures:

Gas, 1,310,000 cu.ft. at 80c. per M	$1048.00
Lubricating oil	86.14
Overhead charges	873.00
Repairs	52.76
Total cost	$2059.90
Total output in kw.-hr.	44,712

$$\frac{2059.90}{44,712} = 4.59\text{c. per kw.-hr.}$$

It will be noted that no labor has been included in the cost. This is because the steam-plant engineer operates the gas-engine unit. Inasmuch as it needs practically no attention, his time for starting and stopping the engine is considered negligible.

Producing current even at this rate is cheaper than buying it from the central station. It should be borne in mind, however, that with a daily output of 207 kw.-hr. the engine was run at half load only. Referring to the curve it will be seen that as the load is increased the efficiency will increase. Hence, as the requirements of the business make greater demands for current the cost per kilowatt-hour will decrease until the full load and capacity limit is reached.

[It will be noted that the overhead charges are extremely high—about 23 per cent. of the installation cost. This is undoubtedly due to the inclusion of other items than depreciation, interest, insurance, etc. However, it is significant that, even at this figure, the cost of producing current is less than that for which it can be bought. —EDITOR.]

Loss of Power at Different Altitudes

The December number of *The Otto Cycle* contains the following table showing the loss of power at different altitudes above sea level, expressed in percentage of the power at sea level:

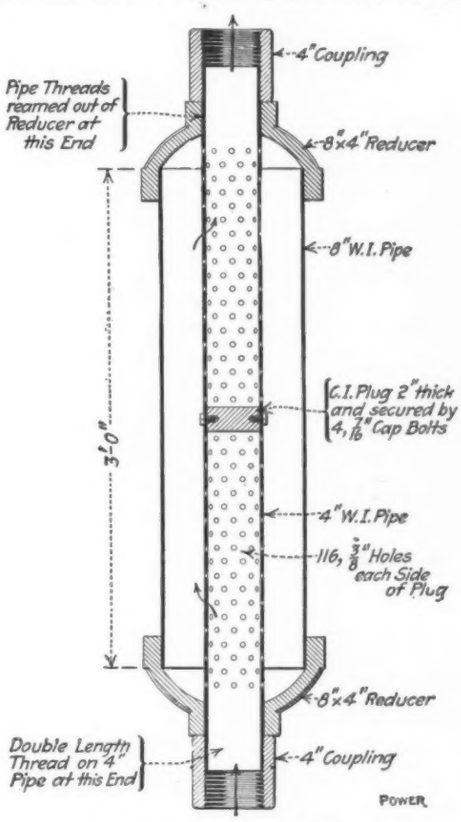
Altitude, feet	Loss in rated horsepower per cent.
1,000	3.55
2,000	6.95
3,000	10.25
4,000	13.45
5,000	16.35
6,000	19.45
7,000	22.35
8,000	25.15
9,000	27.85
10,000	30.45
11,000	32.95
12,000	35.35

CORRESPONDENCE

Exhaust Silencer

A few years ago we decided to use a gas engine to take care of an extra load and purchased a 25-hp. gasoline engine, and, as is the case most medium-sized gas engines, this one came equipped with a cast-iron exhaust vessel. These devices when properly connected, as close as possible to the cylinder, allow the exhaust pressure to drop very quickly and do away with much of the back pressure, but as a muffler or silencer they are not usually of much consequence.

To keep peace with the neighbors, we devised the muffler shown and used it with and connected outside of the



SECTION THROUGH SILENCER

cast-iron vessel. It is easily made, not very expensive, is heavy enough to withstand abuse and has proved very effective as a silencer. The exhaust pipe from the engine to the exhaust vessel is 3½ in., and from the latter to the muffler 4-in. pipe is used, the muffler being designed for this size of pipe. The dimensions given are, of course, for this particular case and would have to be changed to meet other conditions. The total area of the small holes in one end (inlet or outlet) should not be less than the area of the exhaust pipe.

M. C. ST. JOHN.

Houston, Texas.

Briquets are said to be an excellent form for using slack coal in a hand-fired plant. They can be burned at a fairly rapid rate of combustion with good efficiency and with practically no smoke. High-volatile coals when briquetted are perhaps as valuable as low-volatile coals when not briquetted.

REFRIGERATION DEPARTMENT

Corrosion in Refrigerating Systems*

As a preliminary the author gave a short summary of the conditions known to be conducive to corrosion, stating previously, however, that the manufacturers of chlorides for refrigerating purposes have been forced to put on the market chlorides that would not tend to accelerate corrosion.

The conditions briefly are:

1. Combinations of unlike metals with the electrolytic brine.

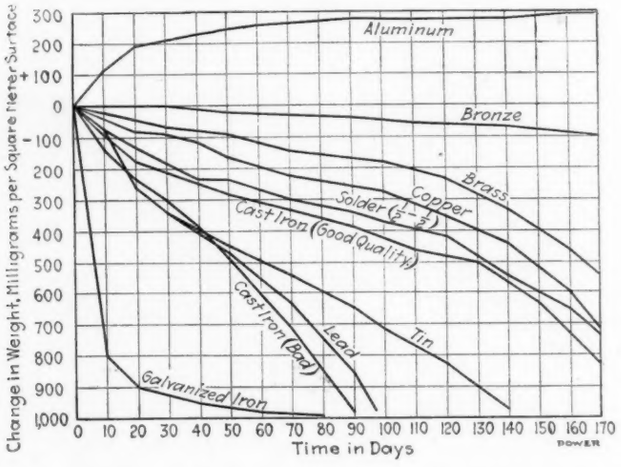


FIG. 1. SINGLE METALS IN CALCIUM CHLORIDE BRINE, SPECIFIC GRAVITY 1.2

2. Combinations of the same or like metals in brine, but of varying degrees of purity, and segregation of impurities.

3. Metal in a state of strain, especially torsional stress.

4. Cutting effect of heavy brines when forced at high velocity through short-turn bends, or through piping of too small diameter relative to the volume of brine carried.

5. The presence of air (oxygen) in the piping, or other apparatus, or in solution in the brine itself.

6. Faulty construction of the brine-carrying apparatus so that the brine originally free from air or relatively so, soon becomes saturated with air (oxygen) and, in consequence, highly conducive to corrosion.

7. Comparatively high brine temperatures which are relatively conducive to corrosion, compared with lower temperatures.

8. The action of electric currents through refrigerating systems, especially the brine-carrying parts.

9. Actual contact with electric current-carrying circuits due to faulty installation of wiring, conduits, etc.

10. Leakage of electric current from poorly installed metallic conduits, which are neither grounded nor insulated from their supports.

11. Poor quality of metal used in the brine-carrying parts of the system, especially in the case of cast iron used in headers, pumps, etc.

12. So-called protective coatings, which in many cases actually accelerate corrosion, rather than inhibit it.

13. Galvanized iron of poor quality, which resists corrosion very well for a short time until the zinc has been dissolved away sufficiently from the iron to extend beyond the limited zone of protection from corrosion. Only the very best grade of galvanized iron should be used, since it is well to bear in mind the evidence that the iron used for galvanized iron is seldom of good quality; and so, once the zinc has dissolved so as no longer to protect the iron, the iron itself will almost invariably be attacked very vigorously.

To show the behavior of metals in brine, tests were conducted covering not less than 100 days—in some cases a year or more—to allow full time for the reactions. The metals, were only seven-eighths immersed in brine, as this simulates a condition very general in practice. The test pieces were 3½ x 1¼ in. in size. The brine was renewed every seven days. The change in weight of the metals was noted at frequent intervals, and calculated in terms of change in weight per unit surface exposed to the action of the brine. The results of such tests on single metals are shown in Fig. 1, the curves representing the general or average behavior of the respective metals in calcium brine at about 73 deg. F.

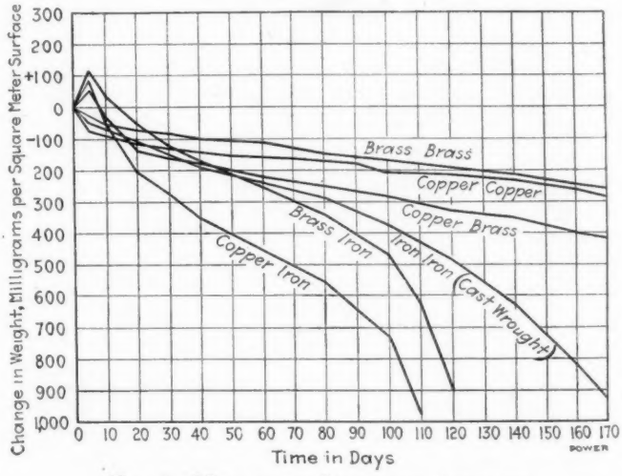


FIG. 2. METALS IN SOLDERED CONTACT

The peculiar behavior of aluminum is characteristic of this metal in a number of solutions and is apparently due to the accumulation of a strongly adherent coating of oxide. Aluminum actually gained in weight on this account.

The alloys seem more resistant to corrosion than do the metals of which the alloy is composed. This is seen in the behavior of bronze and solder.

*Abstract of paper read by Morgan B. Smith before the American Society of Refrigerating Engineers, New York City.

In galvanized iron the great loss during the first ten days' immersion is due to loss of zinc, during which period almost no iron went into solution. At the end of this period there was not sufficient zinc remaining to further protect the iron, with the result that iron began to dissolve along with the remaining zinc. The reaction then gradually assumed the same characteristics shown by the iron of good quality. It is evident that the galvanized iron used in these tests had very good iron as the base.

The figures shown on the chart are not absolute quantitative results, but are merely comparative, under the conditions maintained in the tests. Different conditions might readily alter the comparative results, although those given are fairly representative of the behavior to be expected of the respective metals in brines of any description.

A similar chart was made up for a series of dissimilar metals in contact in brine and a third chart for aluminum combined with several unlike metals and immersed in brine. A fourth chart, reproduced in Fig. 2, shows the results from a number of metals soldered together. The solder seemed to exert an effect similar to that shown by the zinc of galvanized iron, inasmuch as the solder went into solution in each case. The reaction on the metals other than solder was slight, compared with the effect on the solder. The combinations of dissimilar metals show much greater losses than do those of similar metals. These tests were of nine months' duration, only 170 days' tests being shown on this chart, since the general results are well defined during this period. The brass-iron soldered couple continued to show less loss than did the copper-iron soldered couple in these tests.

The gain in weight shown by the brass-iron, the copper-brass and the copper-iron couples was probably due to an accumulation of weakly adherent oxides, possibly due to air (oxygen) in the brine, which was soon used up, after which oxidation was not manifest even on repeated renewal of the brine. The net result of all these tests was to prove that even under the best conditions some corrosion may be expected when single metals, or combinations of dissimilar metals are immersed in an electrolyte such as brine.

Some of these tests were carried out with the metals completely immersed in the brine, the fact being brought out that the losses, when the metals are only partially immersed, are roughly ten times as great per unit of time as when the metals are completely immersed. This only bears out in a striking manner the facts noted in practice, namely, that air (oxygen) must be kept out of the refrigerating system just so far as is possible. Brine-containing apparatus and piping must be kept completely filled with brine, so that air cannot accumulate in high parts of the apparatus. Wherever air does accumulate corrosion will manifest itself sooner or later.

In order that the effect of electric currents, when sent through a system composed of two dissimilar metals in brine, might be noted, tests were made using electric currents of low potential, and of almost no amperage. The effects of very small currents were in proportion to their magnitude, as was expected, the main point brought out being that currents showing a potential as low as one millivolt actually hastened corrosion. The fact was driven home that engineers in charge of refrigerating plants, in their tests for leakage of current, were missing the very currents which in many instances were causing remarkable acceleration of corrosion, if not actually starting the reaction.

Tests for stray electric currents must be made with instruments capable of detecting extremely small differences of potential. It is at local points of increased potential that trouble is likely to appear, due to one or more of the following common sources:

1. Electric motors and generators not properly grounded.
2. Electric motors direct connected on a common shaft with a centrifugal brine pump, and not insulated from the pump in any way.
3. Suspension of electric lamp wiring, frequently for incandescent lighting, and often for arc lamps, directly from the brine lines or other brine-carrying apparatus.
4. Electric wires carrying heavy currents in contact with the apparatus in such a way that the insulation is often completely rubbed through at the point of contact.
5. Electric wiring, such as annunciator circuits, carrying only currents of momentary, small magnitude, but which, through frequent recurrence, often give rise to pronounced action.
6. Poorly installed metal conduits from which current frequently finds its way into the brine lines, etc., as noted above.
7. Sources of current entirely foreign to the refrigerating plant as trolley circuits, arc light circuits, telephone circuits, etc.

Ammonia Compressor Safety Devices*

By Peter Neff

Safety devices for compressors may be divided into those which provide protection against accidents resulting from breakage of parts which go to make up the entire compressor, and those which provide against damage resulting from other than inherent causes. The first class provides against such accidents as the breaking of valves, rupturing of cylinder walls and heads, breakage of piston rods and rings, and the like. The breaking of the valves in the early days was probably the greatest source of damage to compressors, but this defect has to a large extent been eliminated by making the valves from a grade of material which does not so readily tend to crystallize, by constructing the valves so that they are more or less cushioned in their operation, by locating the valves so that the broken parts remain in the pocket in which the valve operates and cannot enter the cylinder, and by the use of a false head in the compressor, covering the entire bore, which is held in place by springs of greater tension than the pressure ordinarily exerted on the head. This method is not applicable except in vertical single-acting compressors.

The second class deals with such accidents as are caused by explosions, unusual pressures, the presence of liquid in the compressor and the like. The best guard

*Abstract of paper read before the American Society of Refrigerating Engineers, New York City.

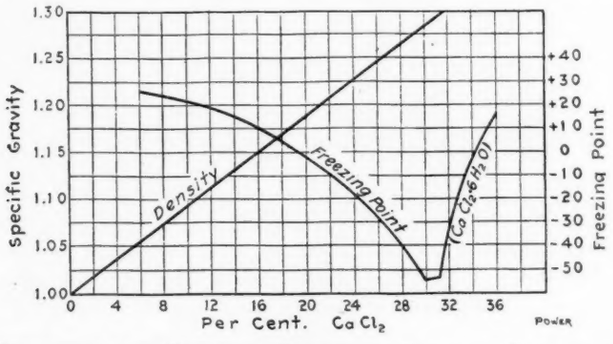
against explosions is judgment and care on the part of the operator. When a machine is started with the discharge valve shut, failure may not take place in the compressor, but in some weaker part of the machine. To avoid this insert a relief valve in a bypass between the discharge and suction sides of the machine. If this device is not used it tends to become useless, and when used too frequently is apt to leak. This method, notwithstanding its faults, seems to be the best available at the present time, and should be improved along the lines of better seating and a better arrangement for operating by hand, so that it can be tested daily.

For protecting against the presence of liquid in the compressor the false head applicable to vertical single-acting compressors would seem to be all that is necessary, but the construction detracts to a large extent from the usefulness of the cooling water, owing to the gaseous space between the false head and the head proper. In small compressors where the discharge valve is of the same diameter as the compresser, satisfactory and safe results are obtained.

❋

Making Calcium Chloride Brine

In the Nov. 5 and the Dec. 3 numbers of POWER I noticed articles on the making of calcium chloride brine by C. E. Anderson and R. A. Cultra. With regard to the method followed in making up this brine I wish to call attention to a very satisfactory manner of dissolving the chlorides. In the brine tank, at the end opposite the outlet, is built a suspended grating of wood or iron with holes about ½ in. in diameter. This grating should be submerged to a depth of at least 12 in. On this grating is placed the chloride, preferably broken up,



DENSITIES AND FREEZING POINTS OF CALCIUM CHLORIDE

although in some cases the whole block from the drum is set on end upon this grating. Into this grating the return brine empties below the surface of the brine, because of the danger of saturating the brine with air.

With such an arrangement the chloride will dissolve rapidly and no large chunks can possibly go to the bottom of the tank there to form a hard mass which will not readily dissolve. There should be, of course, some circulation in the tank to facilitate solution of the chloride and to provide a uniform brine.

Mr. Cultra says that the greater the density of the brine the better, as a much lower temperature can be maintained in the refrigerators, if so desired. This statement is somewhat deceiving, as with calcium chloride there is a limit to which the density of brine may be carried. The relation between specific gravity, freezing points and percentage composition of calcium chloride brine is shown in the accompanying table and in the chart which shows the same relations graphically.

Sp.Gr.	Freezing Pt. deg. F.	Per cent. $CaCl_2$
1.05	+26	6
1.07	24	8
1.087	22	10
1.104	18	12
1.133	15	14
1.143	10.5	16
1.164	4.5	18
1.183	— 3.0	20
1.202	—10.0	22
1.222	—19.0	24
1.242	—30.0	26
1.263	—42.0	28
1.285	—54.0	30
1.295	—53.0	31
1.305	—32.0	32
.....	— 6.5	34
.....	+16.0	36

After reaching a density of approximately 1.285, any further increase means a rise in the freezing point. These extreme densities are not reached in practice, but I know of several instances where engineers in charge have gotten into serious difficulties because they have allowed their brine to become too heavy in chlorides, with the result that the brine congealed at the working temperature and caused no end of trouble.

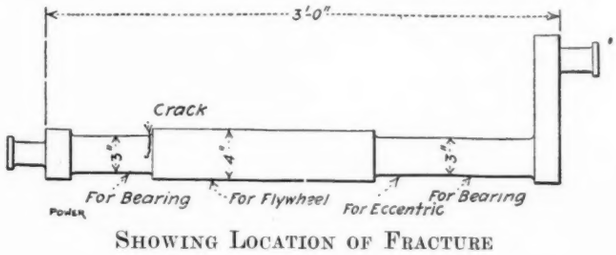
M. B. SMITH.

Detroit, Mich.

❋

A Broken Crankshaft

We have a 10-ton, single-acting, steam-driven compressor running at about 100 r.p.m. Ever since this machine has been installed (about one year) we have



SHOWING LOCATION OF FRACTURE

had trouble with the crankshaft bearing on the compressor side of the unit. Sometimes it would run fine for a week and then the bearing would get hot from no apparent cause. At times it would not take more than 15 min. for it to get hot enough to slow down the machine and then again it would gradually warm up and keep getting hotter for a whole day. Everything we could think of was done, but with no success.

One morning while sitting at the desk I noticed the compressor begin to slow down. Upon going over to the machine I found the bearing almost hot enough to melt the babbitt, and it had been cool only 10 min. before. Feeding it with oil did not help any, so I decided to loosen up on the bearing cap. I had backed the nuts off about one-half turn when the compressor side stopped and the engine began to race. After stopping the engine and taking the cap off the bearing, I found that the crankshaft had broken at the shoulder formed by the body of the shaft with the bearing journal. An examination after removing the shaft showed an old crack and that there had only been about a square inch of metal holding the shaft together.

J. H. STRETTON.

Los Angeles, Calif.

EDITORIALS

Heat Balance in Steam Boilers

It is not enough to know that a boiler evaporates a certain number of pounds of water per pound of coal, even when this performance is reduced to a common basis of "from and at 212." It is not enough to know that sixty per cent. of the heat in the coal has been absorbed by and is present in the steam. The engineer who is going to profit by a boiler test wants to know what became of the other forty per cent. and why that is not in the steam too.

The way to find this out is to make a heat balance; to put upon one side all of the heat furnished to the boiler in the coal and upon the other the amount absorbed and used in making steam, that not developed as a result of incomplete combustion, as by gases going off unburned, coal dropping into the ashpit, etc., the heat carried off through the stack by the hot products of combustion, the heat taken out with hot ashes, clinker, etc., the heat used to evaporate moisture out of the coal and heat it to the chimney temperature, the heat lost by radiation, etc. If one can learn through which of these channels the unabsorbed heat is escaping he may be able to save at least a part of it.

The making of a heat balance has been a difficult and complicated operation, involving an ultimate analysis of the fuel as well as exceptional precision in the determination of the more frequently observed quantities in a boiler test. On page 42 *et seq.* is an article from the pen of Professor Marks, one of the authors of the Marks-Davis steam tables, which shows how such a balance can be made with an accuracy which is within the attainable degree of accuracy of a boiler test itself without having recourse to the ultimate analysis. The article not only explains how the various quantities are determined and calculated but gives diagrams by the use of which much of the calculation is avoided or simplified.

❧

Use of Fuel Oil

While the use of fuel oil for generating steam has made great progress on the Pacific Coast and in other sections having low transportation rates from the Southwestern oil fields, the advantages of liquid fuel have not been realized in many localities because of the dearth of practical information among engineers on the subjects of oil burners and the arrangements of furnaces best adapted to the combustion of liquid fuel. Very creditable contributions have been made to this branch of steam-engineering literature by California engineers and others through the transactions of the American Society of Mechanical Engineers, which give valuable information on the subject.

But a more general introduction of fuel oil need not be looked for until the rank and file of operating engineers and firemen are made better acquainted with the requirements of liquid fuel burning with respect to storage, safety, designs of oil burners, value of different kinds of oils and modifications of present coal-burning furnaces which are necessary to the successful use of liquid fuel.

It would seem that there is room for good practical literature on the subject of oil burning and it is suggested that if the oil trade looks forward to business in this line, it could not do better than to study conditions in different localities, and supply power-plant engineers with practical information on oil burners and boiler furnaces for burning oil under different types of boilers, together with suggestions of methods of adapting the leading types of boiler furnaces to the employment of liquid fuels.

❧

Testing Auxiliary Machinery

Power-plant testing is recognized by most engineers as essential to economy. The prevailing tendency, however, is to confine such tests to boilers and engines, allowing the small auxiliary units to run without knowing definitely as to their condition or efficiency.

For instance, a duplex steam pump, such as is commonly used as a boiler feeder, is exceedingly wasteful of steam when compared with an automatic cutoff engine. The pump does not use as much steam as the engine during a day's run, but the steam consumption per horsepower developed is much greater. It is seldom, however, that power-plant pumps are given a test run. They have been known to operate for years with the steam valves leaking so badly that the exhaust pipe showed a continuous discharge of steam while the pumps were being operated.

Other causes for a pump not working at its full capacity, even if the steam valve and pistons are tight, are scored water cylinders and worn water packing. When pumping against a pressure some of the water leaks past the piston to the other end of the cylinder and, to handle the required amount of water, the pump must be run enough faster to make up for the excessive slippage.

This is wasteful and steam is consumed to push a plunger that is displacing but a part of its maximum capacity. A little attention on the part of the engineer would disclose the waste, when steps could be taken to remedy it.

It is not uncommon to see the vacuum gage of the condenser registering only twenty-four inches. If the gage is correct there is something wrong with the condenser. If a higher vacuum is not carried, say twenty-six inches, then the economy of the engine is reduced according to the difference between the vacuum that is and the vacuum that should be maintained.

An incorrect gage is a defect easily remedied. If the trouble is in the condenser the engineer's first duty is to test it out, ascertain if the supply of cooling water is being interferred with, how the vacuum and temperature check and examine the valve gear of the condenser; the plunger may be making but a partial stroke.

It is not the larger leaks which cripple a power plant, for they are easily detected and the engineer is forced to remedy the evils because they are so apparent, but the small leaks which exist week in and week out, out of

sight and undetected, eat into the plant economy to a much greater extent than most engineers realize.

One small source of leakage may not amount to much in itself, but a number taken collectively are equal to one large leak that would not be allowed to exist in any except a grossly mismanaged plant.

The Value of Tact

That tact is valuable is so evident and universally acknowledged that it scarcely seems necessary to comment on it. However, the very commonness of the desirability of possessing and exercising tact is probably accountable for its being so frequently overlooked. Ask anyone if he has ever known instances where tact has benefited the possessor, or the lack of it worked to the disadvantage of the one devoid of it, and he will immediately recall innumerable such instances. Nevertheless, this same person, within a very short time either before or after the conversation, himself might have committeed an act that indicated a failure to appreciate the value of tact. What is the explanation? Simply that it is a human trait to lose sight of the most obvious things.

Without going into the citation of numerous incidents illustrating wherein tact has profited someone, or its absence accomplished the reverse, only one very ordinary experience will be mentioned. This occurring but a few days ago, brought the subject freshly to mind, hence this dissertation.

A manufacturing plant was in need of the services of an operating engineer. A capable, likely man applied for the position. Looking over the plant he saw ways in which he could improve the plant and both he and his prospective employers were confident of his ability to handle the situation. It so happened that the previous engineer had not been as competent as might have been desired and in consequence the company had engaged a supervising engineer to inspect the plant and recommend changes in its equipment and methods of operation that would make it more economical.

The plant was in immediate need of a new operating engineer so that the factory might continue operation, for it was the busiest season of the year. The applicant for the place agreed to take it, but later, finding that the supervising engineer was not instantly withdrawn, refused to go to work. In short, he quit before he actually started work, in spite of the fact that the company had agreed to dispense with the supervising engineer as soon as it could gracefully do so.

Naturally a self-reliant man feels no need of an outside advisor and may even resent what seems to him as interference. Equally natural is it for the management of an institution to hesitate about cutting itself off too hastily from its previous best help until it is reasonably certain that the substitute contemplated is likely to be satisfactory.

One may say that this engineer showed a lack not only of tact but of good judgment. It would have hurt his reputation not at all to have operated the plant for a season in coöperation with the advisory engineer and without question, he would now be in a good position. Instead he is still out of work and the plant to which he had agreed to come was compelled to lie idle at a very inopportune time. While much may be said on both sides of this case in justification of the course each party pursued, the fact remains that bitterness was engendered, and that the reputation of the engineer is quite likely to have been injured; worst of all is that more tact on either side might have brought about a favorable conclusion.

To realize the most from it, tact must be an innate quality of the man. Unless it comes natural to him he will surely forget to use it when the need arises. False pride and hot-headedness are foes to tact. The man who has no predisposition to the latter should strive the harder to develop it, and in the meantime to subjugate the antagonistic tendencies.

Their Mutual Obligation

The recent holiday season has brought into notice a decided tendency on the part of both employer and employee to give each other credit for acts performed outside the narrow line of duty. This tendency will do much to make their respective positions understood, and when more widely practiced, it will be a power for much practical good.

We do not believe that the giving of money or presents as sufficient recognition of the employee's merit or long service is wholly actuated by selfish motives or by a desire of the employer to pose as an almsgiver or as a philanthropist. Many industrial concerns today have rightly concluded that their success has largely depended upon the skill and interest displayed by their employees, and have therefore chosen the holiday season as a fitting time in which to give this recognition substantial expression. And they are, in a measure, practically canceling a business obligation.

For many years the relations between capital and labor were narrow and distrustful, but now their growing knowledge of mutual dependence has given each a broader, more disinterested view point and created a human-interest element hitherto lacking. This is as it should be.

Undoubtedly the demand for workmen of high intelligence and quick, sound judgment to operate the high-powered, often intricately constructed machines now in use has caused to be superseded the workman with more muscle than brain. Because of this fact, we believe that both capital and labor are adopting a plan whereby each will get the best that the other has to give.

Therefore, we say it is obligatory that capital give its fair meed of praise and compensation to labor, and equally obligatory that labor strive to serve capital's interests with something in mind beyond the mere dollars-and-cents return expected.

The *Kansas City Post* prints illustrations, accompanied by the usual photograph of the inventor, of a wonderful engine, patented and perfected by B. F. Goldsborough, of Joplin. This engine is expected to "save 74 per cent. of the heat used instead of three per cent., as is the case in a common engine, or eight per cent. from a superheated engine." Inasmuch as the better of the present engines convert over 70 per cent. of the heat available in the temperature range through which they work, into mechanical energy, it would seem that Mr. Goldsborough has performed quite a feat, if, as the papers says, his first engine, one of 225 horsepower, has been made and sold, and is a success.

READERS WITH SOMETHING TO SAY

Points about Steam Traps

This letter sets forth the principle reasons why steam traps often fail to perform their duty satisfactorily. There is probably no piece of apparatus around a steam plant that receives less attention and yet has more expected of it than the steam trap.

Failure of traps to operate successfully is often due to one or more of the following causes. First, the trap has not been properly installed. Sometimes the discharge is choked, due to faulty piping, such as too many ells, tees, etc. The discharge should be as straight and free as possible and of the full size of the outlet of the trap. Also in regard to pipe fittings, I have found that the more liberal use of 45-deg. ells and Y's in all piping of this kind gives far better results than 90-deg. ells and tees. Fig. 1 shows right and wrong connections and clearly illustrates the value of the 45-deg. ells and Y's. The trunk lines are shown at *A* and the branches at *B*.

This piping question is one that deserves considerable study and attention because a little careful planning in the beginning will save a lot of expense, work and

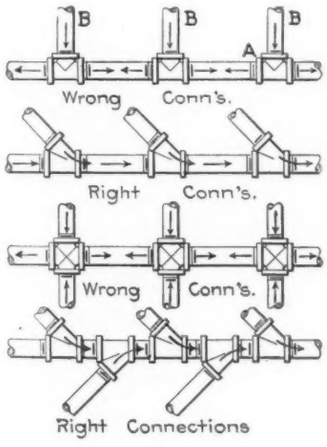


FIG. 1.
RIGHT AND WRONG TRAP DISCHARGE PIPE CONNECTIONS

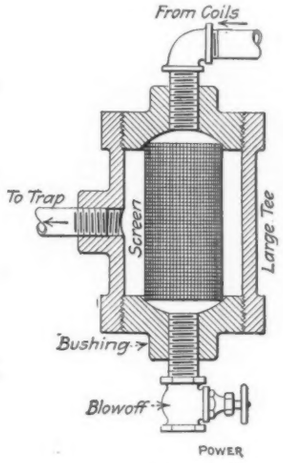


FIG. 2.
STRAINER FOR TRAP

worry, when the installation is completed and will often give results far above the average. Another very important thing which seems to have been overlooked in most cases is to see that dirt and other foreign substances are prevented from getting into the trap and putting it out of commission by plugging up the valve. Some will purchase the finest and most expensive trap and then connect it up to dirty coils or other apparatus before the system has been blown out, and neglect putting any kind of a strainer in the inlet to the trap. Fig. 2 shows a very simple strainer that can be made of pipe fittings and a piece of heavy brass or copper wire screen made in the form of a cylinder so that it will fit into the recess in the bushings.

A trap of the first order is the simple expansion trap and while there are various modifications of it, we will only deal with it in its simplest form. This trap is made of a piece of brass pipe of suitable size and length, mounted in a suitable frame. One end of this pipe is connected to an adjustable valve, while to the other end is connected the return from the steam coils or other apparatus that is to be drained. The operation is as follows: When the water is all blown out and the trap contains only dry steam, the valve is adjusted so that it is just closed, but as the trap fills with water, it causes the brass pipe to contract or shorten in length and by doing so the valve is opened and the water is discharged. The action tends to clean the valves.

Very evidently if this trap is regulated to suit a certain pressure, it may not operate perfectly at some other pressure, because there will be quite a variation in the temperature; this I have found to be the case from actual experience. Then, too, this type of trap will not always take care of a sudden rush of water because there is not always sufficient area in the valve, so we find that while the expansion trap is one of the simplest and most sensitive forms of trap, still to give good results the conditions must be as near ideal as possible, that is, the steam pressure must not vary too much and the flow of the condensate to the trap must be fairly steady and not more than the trap can take care of. I have found that this trap operates best when it is set in an inclined or vertical position with the outlet valve at the bottom because, in this position, as the water rises and falls in the tube, the expansion and contraction is more uniform and there is always a water-seal over the valve.

GEORGE J. LITTLE.

Passaic, N. J.

Troubles of a Feed Water Heater

Where I am employed a new feed water heater has just been installed, and as it at once gave trouble I began a close observation of its action and have found the following faults which may be of interest to others. I might state that the heater was bought without any recommendation on my part.

The boiler at this plant is 48 in. by 15 ft. The heater is 42x100 in. and of the open type. The heater is much too large for the boiler and as the water does not move through it fast enough it loses its temperature. Proof of this lies in the fact that if I run the boiler feed pump quite fast for a few minutes, I get a temperature above 200 deg. F., but when the pump is run at a steady speed thereby keeping a steady water level, the temperature of the feed water falls to about 190 deg. F. Now if the heater was smaller the water would move faster and I would get a higher feed-water temperature.

In the heater a vertical partition divides the lower half into two sections, one is the settling chamber and the

other is the filtering chamber. The raw feed water, as in other makes, enters at the top and flows over a number of trays, mixing with the exhaust steam, and then falls to the settling chamber.

From the settling chamber it goes to the under side of the filter and works up through it to the top where the pump suction enters the heater. From the bottom of the heater to the pump suction is 4 ft. From the pump suction to the overflow is 14 in. If the water supply line should give out I now find that while I have 4 ft. of water below the pump suction there is only 14 in. of available water.

The lower end of the regulating float chamber is connected into the pump suction line and, as soon as the pump is started, water is drawn from the float chamber and the supply valve opens at once.

While at first this seems a good plan, still it does not work out well. It takes some time for the water to work up through the filter; the cleaner the filter the shorter the time. When the filter gets dirty and works slowly the boiler feed pump lowers the water supply on the filtered side very fast and the supply valve is opened wide. Then there is an inrush of raw water which the filter cannot handle fast enough so that the overflow is worked to the limit and the supply of hot water goes to the sewer.

As to the filter itself. If a person is using a real good feed water maybe the filter would not give trouble for a long time after it was properly cleaned. I am using water containing 33 gr. per gal. of solids and the filter becomes so badly choked up in three weeks that I cannot get water through it fast enough to supply the boiler. The material used in the filter is coke with a piece of course burlap at the top and bottom.

W. A. Flannery.

Waukesha, Wis.

[Mr. Flannery's letter seems to indicate that the troubles mentioned are not due so much to improper design of the heater as to the manner in which it is installed and also because the feed water is very high in solid content. Perhaps interested readers can suggest remedies for Mr. Flannery's troubles.—Editor.]

❖

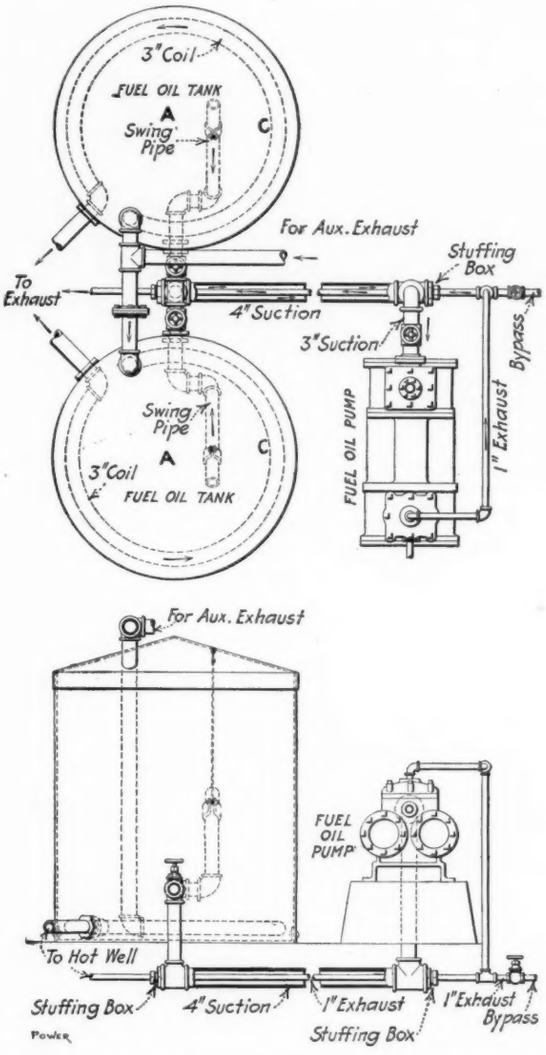
Heating Fuel Oil

The heating of fuel oil to the proper temperature is at times quite a problem, as during the cold weather when the boilers are already overloaded and the fuel consumption is high. I believe we have the problem solved for plants that are operated noncondensing. We use fuel oil of 14 deg. Bé. which is very stiff at 60 deg. F. and apparently gives the best results when heated in the tank to 120 deg. F., allowed to stand at that temperature about four hours (which gives time for most of the moisture to settle) and then heated in a closed line to 140 deg. F. before it reaches the burners.

To get this temperature we use the equipment shown in the illustration.

The two fuel oil tanks *A* and *A* are of 100 bbl. capacity each and each has a 4-in. suction line with a swing pipe which may be hooked to take oil from any desired depth in the tanks. The oil follows the arrows to the fuel oil pump which is a duplex 4½ and 2¾ x 4 in. with a 1-in. exhaust, which, as shown, is connected with a bypass and also through a stuffing-box into the 4-in. oil suction line through the center of which it passes for about 49 ft. and out the other end through another stuffing-box and then on to the hot well.

Each tank contains a 3-in. coil *C* into which exhaust steam from the feed water pumps, etc., is allowed to enter at the top of the tank. It passes down the standpipe around the coil and out at the side to the hot well. This pipe is connected with the lines to an open feed water heater so that any desired amount of the exhaust steam may be used. The coil heats the oil in the tank



Tank, Pump and Connections for Fuel Oil Heater

enough to settle the moisture, but not enough to cause a loss by vaporization. After the oil has entered the 4-in. suction and is on its way to the pump it may be heated to 140 deg. F. or even higher without a loss of the lighter oils or distillates, with this equipment we get the oil through the pump at 140 deg. F. and take out basic silt and moisture to the extent of 0.1 to 0.4 per cent.

B. F. Hartley.

Quail, Calif.

[This fuel-oil heating outfit may be made by the plant engineer at a cost little above that of the tanks, as the necessary pipe and fittings are always available.—Editor.]

QUESTIONS BEFORE THE HOUSE

Buckling of Boiler Tubes

In the August 27 issue, Mr. Davis goes to some length explaining how and why boiler tubes buckle, but in my opinion his ideas were not obtained by actual contact with working conditions.

Actual inspection of hundreds of boilers has taught me that his statement that water tubes always bend upward is misleading.

I have seen water tubes that bent upward but generally the buckling is downward for the very good reason that the bottom of the tube, being nearer the fire, expands more than the top, therefore the bottom of the tube is slightly longer and the tube is compelled to come downward to accommodate this unequal length. Then take, for instance, the common types of horizontal water-tube boilers which have tile covering the upper half of the tubes, these tubes always buckle downward because the fire does not get to the top of the tube and consequently the lower half expands more.

To the engineer who has ever undertaken to prevent a piece of iron or steel from expanding when heated, Mr. Davis' suggestion that scale in a water tube will hold it so tightly that it cannot expand, will seem ridiculous; really it is preposterous to propose that a quarter or even half an inch of boiler scale will have sufficient tensile strength to withstand a force of nature that was used by the ancients to straighten up heavy walls which had got out of plumb. That was done by bracing them up tightly with cold metal and applying heat, causing expansion and the wall had to go back in place.

The experienced engineer has always found that all scale was cracked off a boiler plate or tube which had been overheated.

The statement that tubes in return-tubular boilers either bend downward or loosen at the ends is also near-erroneous.

If Mr. Davis wants to try it just let him have a sleepy-headed fireman let the water down in the boilers so that a couple of inches of the upper tubes are above water line and if they do not bend upward it will be the first case I ever heard of in which they did not. To get a positively heterogeneous style of buckling let him try opening up a blow-off valve and be unable to get it closed again, a good fire under the boiler meanwhile, then when he looks into this boiler he will find buckling toward every point of the compass.

With water at its proper level in a horizontal-tubular boiler a tube rarely buckles, no matter how much scale it has on it. Tubes in a horizontal-tubular boiler are not in the least partial as to which side collects the most scale, it is usually deposited evenly all over the top and bottom alike but I have met with numerous instances where the scale was much heavier on the bottom of the tube than on the top and when a tube gets enough scale to cause overheating it simply expands evenly all around and either bulges the head or slips in the hole.

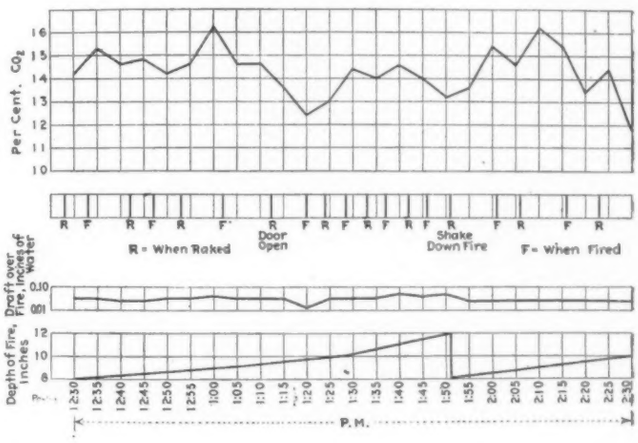
Meanwhile I must confess that I do not know nearly all there is to be learned and would like to hear from others on this, to me, very interesting subject, particularly from those who, like Mr. Davis, have a kind of boiler scale that is so tenacious that neither fire nor expansion will loosen it.

C. R. SUMMERS.

Chattanooga, Tenn.

Results in CO_2

The letter under the heading "Results in CO_2," in the issue of Sept. 10, corroborates the conclusion I reached some time ago. Such results cannot be arrived at as we determine engine performances, by the analysis of indicator diagrams, for unlike engine performances, furnace conditions and the human element are constantly changing in boiler practice. However, the nearest approach



SHOWING CO_2 VARIATION WITH DIFFERENT CONDITIONS OF FUEL BED

that I have discovered for presenting the result graphically is by means of a chart as shown.

The chart covers a period of two hours. The explanation is as follows: Each square represents a period of 5 min. Thus at 1:05 p.m. the CO_2 was 14.6 per cent., the draft over the fire 0.05 in. of water, and the depth of the fire (apparent) was 9 in., three minutes after charging the furnace.

Taking the average for the day of 11 hr. by means of a gas collector and the Hays instrument, gave a result of 12.4 per cent. CO_2 which checks up quite accurately, considering that the collector was working continually during periods of opening furnace doors, cleaning fires, etc.

The evaporation per pound of coal as fired from and at 212 deg. was 9.22 lb.; unfortunately, this figure is lower than usual.

Upon looking over our records of this boiler I find that the last analysis of the flue gases made for deter-

mining the per cent. of CO_2, CO and O upon the following dates showed:

No. 2 BOILER.

	CO_2 per cent.	CO per cent.	O per cent.
July 12	11	0.04	6.2
" 13	11	0.08	6.2
" 15	10.2	0.4	7
" 16	10.6	0.6	6.8

The results are very satisfactory, considering that the boiler is operating at a 50 per cent. underload.

GEORGE C. J. SPANGENBERG.

The Attitude of Many Employers

In a recent editorial in POWER there appeared the statement that the engineer was considered as a necessary evil. With respect to a factory it is useless to say that the engineer is indispensable to the owner and not pick out many other department heads without which the articles manufactured by that particular firm could not be produced. In the same way it is evident that if there was no factory there would be no engineer and so we might go on indefinitely with such conclusions.

The main question is, why should the engineer be a necessary evil any more than the workmen in the shop, for every manufacturer expects to have tools and machinery and most of them expect to have power, and the output depends greatly on the manner in which that power is maintained.

It does not seem reasonable in these days that many employers would think that their engineer need not be a man of considerable intelligence to operate the machinery in a safe and economical manner. Nor do I see where any manager would be justified in making the remark quoted in the editorial that he always knew that it meant some expense when he saw the engineer approaching, unless the employee was unusually careless and negligent.

It has seemed to be usually the case where the owner has a fine modern power plant that he is always glad to show it to his friends and his associates in business and why then should he regard the men to whom he has intrusted the care of this extremely valuable property as necessary evils? The broad-minded employer does not have this feeling if he sees that his engineer takes the proper interest in his work. It is necessary that the engineer try to explain everything to his employer, so that the latter may take the same view of the affairs of the plant that he does and if this is done, there should be harmony between them.

One thing that tends to bring discord between these two is that the engineer does not work by that clock-like regularity as regards the different jobs that he may do each day, as do the workmen in the shop. With them it is an effort to turn out the largest amount of good work in a given time, which is called quick production, while the engineer's part in good production lays in the regularity of service that he makes his plant give and to promote that regularity he may have this part to repair on one day and that on another. In the meantime there may be intervals of apparently idle moments or whole days of very little manual labor, which being observed by the employer, give him the feeling that there is a lazy man in his engine room.

If this conclusion is true, then the operation of the plant will sooner or later show it, but if the appearance of the plant continues to be good and the expenses do not show any unusual increase, the employer should feel that the engineer is doing as well as can be expected.

Another very fruitful cause of trouble is the tendency of some employers to try to make the engineer feel that they "know it all" as many of them do by offering suggestions on how to run the plant. I have been thrown in contact with men who should have had some practical ideas but who had very few. I have heard a man say that a 180-deg. bend in a steam pipe was no better for expansion than a straight piece of pipe with elbows. He could not see why the fire in a high-pressure boiler could not be banked over night and the steam be allowed to flow into the heating system without seriously lowering the water level in the boiler in a period of eight hours. He also could not understand why a building with a large window area exposed to the full force of the wind in the New England climate, could not have the heat shut off all night without anything freezing because in a much more southerly location this practice prevailed in a building of several more stories and which was sheltered by other buildings near-by.

We can well ask the question: Who is the "know-it-all" in this case? Surely not the engineer who needs the patience of Job to listen to such statements and yet if the positions were reversed, how long would the engineer expect to remain if he made such statements?

Then there are many employers who have the honesty to say that they do not know anything about the mechanical end of the business and tell their engineer that he must go ahead and do as he thinks best and that it is up to him not to prove a failure.

In conclusion, we can be sure that no engineer who does not try to give his employer the full value for money received can expect that the employer is going to have the same feeling toward him that he would have if he fully trusted him. When once there is a feeling of suspicion on the employer's part it is time for the engineer to depart for other fields before he is invited to do so.

G. H. KIMBALL.

East Dedham, Mass.

How the Pump Valve Deck was Cracked

In answer to Mr. McGinness' inquiry, I would say the crack was caused by internal stresses in the division wall. The walls of the casting being very thick, 1½ to 2 in., the cracked part looks to be of very small cross-section compared to the thickness of the walls of the casting. When the casting was cooling in the mold the sides and ends would naturally cool first, radiating heat in every direction, leaving the division wall to cool last. This being the case, and as cast iron shrinks on cooling from a red heat, the internal wall would be subject to tension causing the internal stress mentioned. In service, no doubt, the temperature of the air surrounding the pump was higher than the water forced through the valves, this would also increase the stresses on the division wall and on the top valve deck. This fracture is not due to an increase of the discharge pressure for the gaskets in the pump and line would give way before the wall would fracture.

ELLSWORTH TONKIN.

Columbus, Ohio.

INQUIRIES OF GENERAL INTEREST

Whistling Sound in Boiler

When a boiler occasionally makes a whistling sound as the firedoor is opened or the damper closed slightly, what causes it, and can any harm result?

W. C.

This sound is probably the noise made by the air passing through the firedoor crevices. Beyond admitting more air than is necessary for complete combustion, thus reducing economy, no harm is done.

Relative Efficiency of Return Tubular and Locomotive Boilers

Which is the more efficient, the return-tubular or the locomotive boiler?

C. W.

The return-tubular boider is generally more efficient when properly designed, well set and having good draft. It also has better furnace combustion and less loss of heat by radiation and generally in the chimney as well.

Automatic Stop Governor

What is the function of an automatic stop governor?

E. D.

The automatic stop attachment on a throttling governor usually is an idler pulley resting on the governor belt, the supporting arm of the pulley being connected to the governor so as to automatically shut off the steam if the governor belt breaks or comes off. On Corliss engines various contrivances are used to accomplish the same or the equivalent function of such an attachment. The most common of these is the safety knock-off cam.

Working Strength of Joint

What would be the allowable pressure in a boiler 60 in. in diameter with a shell ½ in. thick having a joint efficiency of 68 per cent. and constructed of metal having a working strength of 9000 lb. per sq.in.?

R. E. R.

The working strength of the joint per inch of length of shell would be

$$9000 \times \tfrac{1}{2} \times 0.68 = 3060 \text{ lb.},$$

therefore, in a longitudinal joint the allowable boiler pressure would be

$$\frac{2 \times 3060}{60} = 102 \text{ lb. per sq.in.}$$

Heating Surface in Pipe Coil

How is the heating surface estimated of a wall coil of four 1-in. steam pipes as used in factory heating systems?

J. K.

Base the heating surface upon the superficial pipe area, neglecting the small increase of heating surface due to fittings. The outside diameter of 1-in. steam pipe is 1.315, and the external circumference 4.131 in.: therefore a 1-ft. length has

$$\frac{4.131 \times 12}{144} = 0.344 \text{ sq.ft.}$$

In a four-pipe coil each foot-length of coil has

$$4 \times 0.344 = 1.376 \text{ sq.ft.}$$

of heating surface.

Lift of a Safety Valve

What is the lift of a safety valve?

N. B.

It is the distance which the valve rises vertically above its seat.

Finding a Chimney's Least Diameter

What should be the least internal diameter of a chimney 81 ft. high, if 2.88 lb. of coal are burned per horsepower per hour and the horsepower is 160?

E. R. R.

According to Kent's formula, where allowance is made for burning 5 lb. of coal per horsepower per hour,

$$\text{Hp.} = 3.33 \times \text{E} \sqrt{\text{H}}$$

where

Hp = Horsepower

E = Effective cross-sectional area of the chimney in feet,

H = Height in feet.

In burning 2.88 lb. per horsepower per hour the formula is adapted to the conditions by dividing by 5 and multiplying by 2.88, whereupon, with the substitutions indicated, it becomes

$$160 = \frac{2.88}{5} \times 3.33 \times \text{E} \sqrt{81}$$

By transposing and solving,

$$\text{E} = 9.268 \text{ sq.ft.}$$

which equals the area of a circle the diameter of which is 3.44 ft., or about 3 ft. 5¼ in. For round chimneys the actual diameter should be 4 in. greater to allow for friction, or 3 ft. 9¼ in.

Determining Equivalent Evaporation

In making a test on a boiler having 105-lb. pressure, with feed water at 305 deg., how is the evaporation at 212 deg. worked out?

G. J.

The equivalent evaporation from and at 212 deg. F. and atmospheric pressure is the actual evaporation multiplied by the factor of evaporation. The latter is determined by dividing the total number of heat units received per pound of water by the heat units required to convert one pound of water at 212 deg. into steam at atmospheric pressure; i.e., by the latent heat of evaporation which, from and at 212 deg. F. and atmospheric pressure, has been determined to be 970.4 B.t.u. This is based on a heat unit being considered as $^1/_{180}$ of the heat required to raise a pound of water from 32 to 212 deg. F. The formula is

$$\frac{\text{H} - \text{h}}{970.4} = \text{Factor of evaporation}$$

where H is the total heat above 32 deg. in the steam and h the total heat above 32 deg. in the feedwater, both found from steam tables. In this case the steam pressure was 105 gage, which equals

$$105 + 15 = 120 \text{ lb. absolute.}$$

According to the Marks and Davis steam tables, to raise 1 lb. of water from 32 deg. F. to 120 lb. absolute pressure would require 1189.5 heat units, which is H in the formula. The feedwater temperature being 305 deg. F., h would equal

$$305 - 32 = 273 \text{ deg. above 32 deg.}$$

To be more exact h may be taken from the steam tables, corresponding to 305 deg., where it is found to be 274.7 B.t.u.

The factor of evaporation then is

$$\frac{\text{H} - \text{h}}{970.4} = \frac{1189.5 - 274.7}{970.4} = \frac{914.8}{970.4} = 0.9427$$

Leakage of Furnace into Front Smoke Connection

In firing a 66-in. by 16-ft. flush-ended return-tubular boiler with natural gas the boiler front gets very hot and it is sometimes difficult to generate enough steam. When coal was used as fuel there was sufficient draft and no difficulty in making all the steam that was required. What is the cause and remedy for the trouble?

G. W. P.

The difficulties are probably due to the passage of burning gases direct from the furnace to the front uptake through cavities in the front furnace wall, or to imperfect sealing-off of the furnace from the front connection at the front end of the boiler.

Relation of Ammonia Compressor Cranks

On a double-acting horizontal ammonia compressor, how should the cranks be set to get the best results in steam consumption and steady speed?

J. H. S.

The crank for the steam cylinder of a compressor should be set at 90 deg. with the compressor-cylinder crank. The compressor will not run smoothly if the flywheel is too light. For a given weight of flywheel, there will be a steadier motion if the steam-cylinder and compressor-cylinder cranks are set at 90 deg. to each other than when placed at 180 deg.

ENGINEERS' STUDY COURSE

Logarithms—Part I

We have learned in recent lessons how to extract the square and cube foot. We have learned, too, that the product of several powers of the same quantity is that quantity raised to the power indicated by the sum of all the exponents. Thus

$$8^2 \times 8^3 = 8^5$$

because

$$8^2 = 8 \times 8$$

and

$$8^3 = 8 \times 8 \times 8$$

and

$$8^2 \times 8^3 = 8 \times 8 \times 8 \times 8 \times 8 = 8^5$$

You can raise a quantity to any power by multiplying it by itself the indicated number of times, thus

$$8^7 = 8 \times 8 \times 8 \times 8 \times 8 \times 8 \times 8 = 2{,}097{,}152$$

You can get any root of a quantity by taking the square root as many times as 2 will go into the index of the required root. Thus to get an 8th root, as

$$\sqrt[8]{2434}$$

you extract the square root

$$8 \div 2 = 4 \text{ } times$$

When the index is an odd number subtract 3 from it, divide the remainder by 2, extract the square root that number of times and then take the cube root. Thus to get the seventh root.

$$7 - 3 = 4; 4 \div 2 = 2$$

so we take the square root twice and then the cube root, and the sum of all these indices or exponents will be

$$2 + 2 + 3 = 7$$

All this would involve much figuring, but fortunately it is not necessary. The use of logarithms enables one to perform operations involving roots and powers with great simplicity.

In the following table a series of numbers in geometrical progression, 1 — 2 — 4 — 8, etc. (see lesson Dec. 17) is made to correspond with a series of numbers in arithmetical progression 0 — 1 — 2 — 3, etc.

Number	Logarithm
1	0
2	1
4	2
8	3
16	4
32	5
64	6
128	7
256	8
512	9
1,024	10
2,048	11
4,096	12
8,192	13
16,384	14

The numbers in arithmetical progression are the logarithms of the corresponding numbers in geometrical progression "to a base of 2."

The sum of the logarithms of any numbers is the logarithm of the product of those numbers. For example,

The *log.* of 4 = 2
The *log.* of 64 = 6
The *log.* of 256 = 8

Adding the logarithms of 4 and 64 together we obtain 8, the number corresponding to which is 256, which is the product of 4 and 64.

Again,

The *log.* of 2 = 1
The *log.* of 16 = 4
The *log.* of 512 = 9
The *log.* of 16,384 = 14

This same thing would apply to multiplying a number by itself, thus:

The *log.* of 8 = 3
8 = 3
8 = 3
The *log.* of 512 = 9

To multiply three 8's together, i.e., to raise 8 to the third power or "cube" it, we might add three of its logarithms together, which would give 9, which is the logarithm of 512, the cube of 8, for

$$8 \times 8 \times 8 = 512$$

But a simpler way would be to multiply the *log.* of 8 by 3

log. 8 = 3
exponent = 3
log. 8^3 = 9 = *log.* 512

Hence: ***To raise a number to any power multiply its logarithm by the exponent of the given power.*** *The product will be the logarithm of the power required.*

Division by Logarithms

To multiply two numbers together we added their logarithms. Division is the opposite of multiplication, so we can divide by subtracting logarithms.

Subtract the logarithm of the divisor from the logarithm of the dividend. The remainder will be the logarithm of the quotient.

Example: Divide 16,384 by 512.

log. 16,384 = 14 = (*log.* dividend)
log. 512 = 9 = (*log.* divisor)
log. 32 = 5 = (*log.* quotient)

To raise a number to a given power we multiplied the logarithm by the exponent of that power, obtaining the logarithm of the power as a product.

Getting a root is the opposite process to finding a power and may be done by the opposite process of division.

To find the root of a given number, divide the logarithm of the given number by the index of the root. (2 for the square root, 3 for the cube root, etc.) The quotient will be the logarithm of the required root.

Example: What is the cube root of 4096?

$$\textit{log.}\ 4096 = 12$$
$$\text{index} = 3$$
$$= 4 = \textit{log.}\ \text{of the cube root}$$

The number corresponding to the logarithm 4 is 16, which is the cube root of 4096. (See if it is not.)

$$16 \times 16 \times 16 = 4096$$

What is the value of $64^{\frac{3}{2}}$

As has been explained in a previous lesson (Dec. 24) this means that 64 is to be raised to the third power and then the square root extracted. It is, therefore, the square root of the cube of 64. But $\frac{3}{2} = 1.5$, and the expression can equally well be written $64^{1.5}$. This says

raise 64 to the 1.5th power. This would be complicated by ordinary arithmetic, but see how easily it is done by logarithms:

$$\begin{array}{l} \textit{log.}\ 64 = 6 \\ \text{exponent} = 1.5 \\ \hline \textit{log.}\ \text{of}\ 64^{1.5} = 9 = 512 \end{array}$$

Let us see if this is right. It was to be the square root of the cube of 64. Then the cube of 64 must be

$$512 \times 512 = 262{,}144$$

and it is because

$$64 \times 64 \times 64 = 262{,}144$$

You have probably noticed before this that this is an incomplete table even as far as it goes. There is no logarithm given for 3. It would be somewhere between 1 and 2. Likewise the logarithms for the numbers between 8 and 16, in a table made like this one to a base of 2, would lie somewhere between 3 and 4.

The tables of logarithms in ordinary use, called "common logarithms" are made to a base of 10 as follows:

No.	log.
1	0
10	1
100	2
1,000	3
10,000	4
100,000	5

The logarithm of 1 is 0 in any system. In this system the logarithm of 10 is 1. The logarithms of the numbers from 1 to 10 lie between 0 and 1, as follows:

No.		log.
1	=	0.0000000
2	=	0.3010300
3	=	0.4771213
4	=	0.6020600
etc.		

The logarithms for the numbers between 10 and 100 lie between 1 and 2 and consist of 1 plus a decimal fraction, as, for example:

No.	log.
10	1.0000000
23	1.3617278
92	1.9637878

The logarithms for the numbers between 100 and 1000 are between 2 and 3 and consist of 2 plus a decimal fraction, as, for example:

No.
100 = 2.0000000
279 = 2.4456042
672 = 2.8723693

The logarithm is thus seen to consist of an integer and a decimal fraction. The integer is called the "characteristic" and is always one less than the number of integer places in the number. The decimal fraction is called the "mantissa." Thus in the

$$\textit{log. of}\ 279 = 2.4456042$$

2 is the characteristic and .4456042 is the mantissa. The *log.* of a wholly decimal number is "negative," i.e., it is less than nothing. Remember that. Thus the characteristic of the *log.* of 0.048226 is $\bar{2}$. Notice the minus sign over a number indicates that it is negative.

The reader who cannot use logarithms is urged to study well each lesson so that he may be prepared for succeeding lessons that are to appear. In the next lesson we will learn how to use logarithmic tables, i.e., learn how to find the *logs.* of given numbers and given numbers when the *logs.* are known.

Practice Questions

(1) What is the chief purpose of logarithms?

(2) What is the base of the system of common *logs.*?

(3) To what numbers do the following characteristics relate: 0, 1.; 2.; 3.; 4.?

(4) Give the rules for the use of logarithms in performing examples in the following: (a) multiplication; (b) division; (c) raising a number to a given power; (d) finding the root of a given number.

Answers to Last Week's Problems

(1) 211.

(2) (a) 0.9283; (b) 1.357; (c) 5.9721.

(3) 85,184.

(4) 13.88 in.

(5) $\dfrac{92 \times 20}{200} = 9.2$. $\sqrt[3]{9.2} = 2.095$ in., say 2 in.

Study Course Exchange

The following are additional names of those desirous of exchanging lesson papers with others who are following the Course:

John E. Ketchem, Simsburg, Conn.; George H. Reed, N. S. Indian School, Santa Fé, N. M.; D. A. Dickinson, 441 South Piere St., Lima, Ohio.

Fire Brick Melting Points

The United States Bureau of Standards has defined the melting point of firebrick as being the lowest temperature at which a small piece of brick can be seen distinctly to flow. The following melting points of important materials in firebrick were determined:

Kaolin, 1740 deg. C.; pure Al_2O_3, 2010 deg.; pure SiO_2, 1750 deg.; bauxite, 1820 deg.; bauxite clay, 1795 deg.; chromite, 2180 deg. Silicon carbide begins to decompose at 2220 deg. after prolonged heating, but does not melt at much higher temperatures with short heating. Forty-one samples of fireclay brick were tested, the melting points of which were from 1555 to 1725 deg. C.; eight samples of bauxite brick had melting points from 1565 to 1785 deg.; three of silica brick from 1700 to 1705 deg.; one chrome brick gave 2050 deg. and one magnesia brick gave 2165 deg.

Recording Analyzers for Power Plants

By F. D. Harger

Whenever an average American power plant is visited one cannot help but wonder why it is that so little is done regarding the economical control of boilers and furnaces.

Most steam users have been content to leave the problem of stoking entirely in the hands of the firemen, who handled the furnaces guided only by their "experience."

Even the best fireman cannot tell the steam pressure carried without a pressure gage. He cannot judge the correct draft pressure, thickness of the firebed, or whether he is feeding coal properly, by looking at his fire, any more accurately. In many ways we are far behind the times as regards fuel economy and furnace control.

The burning of fuel in a furnace is purely a chemical action and a remedy for existing conditions has been found and is widely adopted in Europe, namely, the continuous and automatic analysis of the products of combustion.

It is not necessary to have a laboratory in the boiler house or employ an expert chemist to see what one is doing. There are instruments on the market, which in

every way are accurate and reliable, are far beyond the experimental stage and are suitable for use in the most exposed positions in boiler plants. On several occasions I have used CO_2, and CO recorders and have found them capable of obtaining accurate results under the most trying conditions.

Much has been said about CO_2 recorders and many may have wondered whether they are of any practical value. They are as indispensable to the working of a boiler as the steam-engine indicator is to the proper operation of an engine.

Combustion of fuel involves a chemical union between the fuel and atmospheric oxygen with the subsequent release of heat and the formation of carbonic acid gas, CO_2, which is the ultimate product. It is evident that the percentage of CO_2 present in the exit gases must serve as the only important and reliable guide to the control of a furnace. The presence and percentage of this CO_2 can only be determined by chemical analysis. The table shows the loss of fuel in relation to the percentage of CO_2 in the exit gases.

Percentage of CO_2	16	15	14	13	12	11	10	9	8	7	6	5	4	3
Loss in fuel, %	10	12	13	14	15	16	18	20	23	26	30	35	45	60

From this it follows, that if a low percentage of CO_2 is discovered in the exit gases, considerable heat is being lost which should be transmitted to the water in the boiler tubes and a high percentage of this gas would indicate that most of the heat generated has been developed by the combustion of any given amount of fuel.

For makers of producer gas, water gas, etc., it is obvious that the knowledge of the percentage of CO is very important, although a continuous record of CO is not absolutely necessary in common boiler house practice. An occasional test is generally sufficient. A CO recorder stands in the same relationship to a producer plant that a CO_2 recorder does to a boiler furnace. In both cases the percentage of gas analyzed should be as high as possible. Blast-furnace gases, coke-oven gases, etc., are in the same category and improved efficiency may be confidently expected from plants where analyzing instruments are installed.

To the thinking man it will be apparent that the installation of an effective instrument for fuel or gas control is a paying investment.

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Pittsburgh Smoke Abatement League

The Smoke and Dust Abatement League, in Pittsburgh, was organized Dec. 9 at a meeting of about 40 representatives of local civic organizations. It was decided to hold an exhibition at which the evil done by smoke will be shown, as well as the modern and approved methods which have been made available for its prevention.

W. T. Todd was elected president and appointed the following plan and scope committee, which will suggest persons to fill the other offices and make arrangements for the proposed exhibition: W. E. Snyder, mechanical engineer; Dr. A. A. Hamerschlag, of the City Planning Commission; Dr. R. C. Denner, of the University of Pittsburgh; O. P. Hood, chief mechanical engineer of the United States Bureau of Mines, and Miss H. M. Dermitt, secretary of the Civic Club of Allegheny County.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Brother Stephenson, of Elko, Nev., quoting from the "American Machinist," notes that "the Berliner Werkzeugmaschinenfabrik A. G. vom L. Leutner, Berlin, Germany, has built a planer 49 ft. long." We were beginning to feel grateful for this nugget of information when we met up with this trifling persiflage: "It would have to be that long to carry the name-plate." You get old Steve, don't you?

Just when many cities have tacked up "No Smoking" signs and hired smoke inspectors to seek whom they may devour in plants and factories, along comes an artist of European renown (whatever that is) who says: "Smoke and dirt tone down the building outlines and give them a soft, artistic color that is pleasing." Now, what do you know about that? Remember when your dad used to tone down your outlines when he caught you smoking behind the barn? Don't put any stress on this artistic bunk; watch your chimbley, and let science triumph over art for once.

White marble is "bad for gravestones," says the U. S. Geological Survey press bulletin. We are indebted to the bulletin for many little shop kinks, but in touchin' on gravestones, it makes a grave mistake. We are, we hope, a long way from being tucked beneath the daisies, so why should this pessimistic investigator upset our mental equilibrium by intruding this dread information upon us? To our mind, it's just the other way: gravestones are bad for us! The cutest little marble affair that ever emerged from the quarry could not tempt us personally to use it. There are times when a press censorship would be welcome.

R. O. Richards, up to Framingham, Mass., writes us that he believes in practicing economy in the plant, but when the chief insists on a man opening the window before looking out, to save wear on the glass, economy gets on one's nerves. Sounds like a paneless joke?

Mebbe you never knew Billy Blivins, over to Boston? You know the type, anyway. Billy could lean up against the rail with ten other fellows, take ten "comforters," and go home in a fair state of ebriety. Billy never "came across" himself. One day, however, hopes (don't omit the "e," linotyper) ran high when he apparently thawed under the internal heat he was generating. He rammed his hand into his loose-change pocket, threw out his thirty-four chest, put one foot on the rail, and chirped: "Well, boys, what are we goin' to have—rain, or snow?"

"Choosing a misfit vocation and lacking mechanical intuition make most mechanics dissatisfied," says a writer in the "American Machinist." You're right, son. We once knew an undertaker who was too jolly to take his vocation seriously, and an engineer who should have been a housewrecker.

A German scientist has double-crossed Doc. Osler by contending that a man is at his best at 50. Osler said 40; that at 60 he (the workman) was useless. Why, you and I know men who were worse than useless at 25, and they lived up to it all their lives. On the other hand, "Leslie's Weekly" recently published thumbnail portraits of eight Pennsylvania engineers who were over 90, and one was 95! Any one of them looks fit to leap into his cab, pull her wide open and refuse to slow down if he saw old man Osler on the track just ahead of the engine.

A stream of some three hundred million dollars flowed into Charity reservoir during 1912. Well, it's one of the best built reservoirs within our ken, and has had no very bad leaks or breaks. There may come times when we will wish that the "riparian rights" had been granted to more deserving consumers, but doubtless this stream will flow out again much less rapidly, screened of the fungi of greed and distilled of its impurities.

Whoops and bangs rose loudly above all the other noises in the plant, and everybody looked toward the outside door. Horan, the chief, sent Doran out to find the reason. "All right, chief," said Doran on his return from the yard; "it's only Kelly. He's breaking his New Year's resolutions!"

Sometimes, in his eagerness to impress his prospective employer, the applicant overdoes it. Jimmy Bates did. He wanted a job firing and tackled the chief. "I'm strong, willing and able to do a big day's work." The chief said nothing. "Why," said Jimmy, "I can do as much as my old man and my brother together. You know them, chief, they're firin' for you now." "You can, eh?" snapped the chief; "come to work in the morning. I'll fire the old man and your brother. You can take their places."

New York Engineers' Entertainment and Reception

The combined associations of the National Association of Stationary Engineers, of Manhattan and the Bronx, held a large open meeting and entertainment on Friday, Dec. 27, in the Engineering Societies Building, New York City, where a reception was tendered to National President John F. McGrath; National Vice-president James R. Coe; National Secretary Fred W. Raven; National Treasurer Sam B. Force; National Trustees Reynolds, Kerley and Brownhill, Past National President Edward F. Kearney, and other national officers. This is the first time in the history of the national association that so many of the national officers were entertained under one roof, coming as they did from all parts of the country.

"THE GRAND MARCH" OF THE N. A. S. E. NEW YORK CITY ENGINEERS

The addresses of the officials were on the welfare of the association, and were well received by a large and enthusiastic audience. The entertainment provided during the evening was furnished by Herbert Self, Joe McKenna, Billy Murray and Jack Armour.

On Dec. 28, at Terrace Garden, the associations held what was undoubtedly the largest and most successful ball ever given under N. A. S. E. auspices. The decorations were unusually artistic. Fourteen past national presidents attended and at the close a supper was given the grand officers.

The general committee was composed of Robert Johnson, chairman; Lorenzo S. Everson, vice-chairman; William M. Logan, treasurer; Frederick Felderman, secretary, and 40 members from the 10 combined associations. Seven numbers on the entertainment program were furnished by professional favorites from the vaudeville stage and were much enjoyed.

NEW PUBLICATIONS

MODERN ORGANIZATION. By Charles DeLano Hine. The Engineering Magazine Co., New York City, N. Y. 110 pages; 5x7½ in.; not indexed. Price, $2.

This book is the latest addition to the Works Management Library. The matter originally appeared in "The Engineering Magazine," from January to July, 1912.

As Major Hine's work has been on the Harriman Lines, the application of his doctrine has been to railroad activities. Although very little detail of application and results are given, the use of the system apparently involves but slight physical change in the organization. It rather reaches its results through a policy of mental suggestion, accompanied by means for establishing and fostering individual responsibility.

The book is divided into eight chapters: The Unit System on the Harriman Lines; Operation of the Unit System; Broadening of the Ideals of Line Supervision; Over-specialization; Fallacies of Accounting; Supplies and Purchases; Line and Staff; Genesis and Revelation of Organization.

The necessity of training subordinates is emphasized by the statement that "The best experts are those who can impart a working knowledge to the layman."

One aim of the system is to free executives from detail, so that under the changed conditions "more energy is now expended in seeing that instructions already issued are carried out." An important feature is the recognition of the desirability of promoting personal relations throughout the entire organization.

COAL: ITS COMPOSITION, ANALYSIS, UTILIZATION AND VALUATION. By E. E. Somermeier. McGraw-Hill Book Co., New York City. Cloth; 175 pages; 6½x9½ in.; 8 illustrations. Price, $2.

To acquaint especially the mechanical and power-plant engineer, the chemist and the non-technically trained man and operator with the purchase and selling of coal is the purpose of this book.

It begins by treating the subject of the constituents of coal and the calculation of the heat value by proximate analysis. The paragraph in Chapter 1 on "Moisture" is instructive and very practical. Chapter III, on "Sampling" should be read by all who purchase coal on the heat value basis. Relative to securing a representative sample the author says: "Too much emphasis cannot be laid on the importance of care and thoroughness in taking and handling the sample on which the chemical results are to be obtained." Again, ". . . as much or more time or money may be expended in securing a sample as is expended in having it analyzed."

Methods of coal analysis are then taken up and followed by directions for the determination of the calorific value of fuel. The next chapter discusses the possibilities of getting rid of the sulphur pyrite in flake or lump form by washing the coal.

The chapter on the "Purchase of Coal under Specification" contains interesting abstracts of the specifications of some large cities as quoted from the "Municipal Journal." The author advises paying premiums or bonuses on coals that are better than specifications call for and also believes that a penalty should be imposed on a seller if the coal is below the specified grade.

The book is concluded by a chapter on flue-gas analysis and a number of analytical tables of many kinds of coal.

This book should prove especially useful to power-plant men.

MECHANICAL EQUIPMENT OF FEDERAL BUILDINGS. By Nelson S. Thompson. Second revised edition. Williams & Wilkins Co., Baltimore, Md. Cloth; 6x9 in.; 272 pages. Price, $2.

The purpose of this book, written by the chief mechanical and electrical engineer, Office of the Supervising Architect, Treasury Department, is to set forth the basic data used in designing the mechanical equipment for all buildings under the control of the Treasury Department.

As this book goes so thoroughly into the specifications, costs, tests, requirements and merits of the various kinds of mechanical equipment for federal buildings, the most the reviewer can do is to enumerate the classification of such equipment, which is as follows: Heating and ventilation; plumbing, drainage and water supply; gas piping; conduits and wiring systems, including telephone and watchman and time-clock system; lighting; elevators; small power plants; motors and controlling apparatus; vacuum cleaning systems and operating data. The appendix, which comprises 72 pages, contains two papers, one on "Commercial Practice" in regard to factory heating and forced hot water circulation systems, by H. C. Russell, and the other on "Heating by Forced Circulation of Hot Water from a Central Station," by Leon A. Warren.

The last chapter of the appendix on "Suggestions to Superintendents" is of great value, not only to superintendents of federal buildings under erection, but to those in charge of the installation of the mechanical equipment in any building, particularly an office building.

One thing noticeable about this book is the practical manner in which all of the many branches of equipment are treated. They are dealt with just as a practical, strictly business-like consulting engineer should carry on his work—simply and thoroughly.

While the book is most valuable to those connected with the office of the Supervising Architect of the Treasury Department, all contracting and consulting engineers as well as architects will find it useful. The book also abounds in helpful information for operating engineers of office building plants.

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West Penn Electric Banquet

Covers were laid for 56 persons at the fourth annual banquet of the West Penn Electric Co., held in the New Zimmerman House, Greenburg, Penn., Dec. 11, 1912. The regular monthly meeting was held in the hotel parlors at 11 a.m., previous to the banquet. W. R. Kenney, superintendent of lighting, presided over the first period, later turning the meeting over to District Superintendent William Snite, when papers were read by E. I. Barnard on "Electric Motors vs. Gas Engines," and L. T. Jackman on "Meter Reading and District Work."

The dining-room decorations bore out the holiday spirit, and a concealed orchestra furnished excellent music for the banqueters.

With Mr. Kenney as toastmaster, responses were made among others by E. D. Dreyfus, statistician; H. P. Chambers, superintendent of lighting; T. S. Henderson, manager of the new business department, of the Pittsburgh office; F. A. Moesta, district superintendent at Kittanning, and W. S. Anderson, chief clerk of the Connellsville office.

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Seventh Annual Banquet of the Southern Power Co.

The seventh annual banquet of the Southern Power Co. and allied interests was recently held in the auditorium, Charlotte, N. C., about 500 guests being present, including Dr. W. Gill Wylie, vice-president, and R. B. Arrington, secretary-treasurer, from New York, the local officers and those resident at Spartanburg, Greenville, Anderson and other points in South Carolina.

Vice-president W. S. Lee acted as toastmaster. After the banquet he happily introduced each speaker, and urged that all present consider themselvs members of one big family. Telegrams of congratulations were read from J. B. Duke, president of the Southern Power Co.; B. N. Duke, vice-president; J. M. Bradshield, and John Frazier, Hobart, Tasmania. Mr. Frazier recently went from the local offices to Tasmania to construct a large hydro-electric plant for the British government.

Dr. Wylie, the first president and founder of the Southern Power Co., as the principal speaker, delivered an interesting address reminiscent of his early interest in the development of water power on the Catawba River and of the early days of the Southern Power Co.

Following Dr. Wylie's address the lights were turned out, and on a screen at the rear of the auditorium was shown one of the company's power plants on the Catawba River. The electric lights gleamed through the windows of the structure on a storm-ridden night, forked and zigzag lightning flashed through make-believe clouds in a startlingly realistic manner and torrential rain descended. The climax of the scene was the wrecking of a transformer.

A parody on "Alexander's Rag Time Band" by a double quartet was one of the decided hits on the program. The singers, equipped as a lineman's crew, paraphrased the ragtime melody into the vocal declaration that the Southern Power Co. was the grandest in the land.

PERSONALS

R. Bowen, for some time past the general sales manager of the Epping-Carpenter Co., Pittsburgh, Penn., has been promoted to the position of general manager of that company.

C. E. Harrison has resigned as chief engineer of the Bell Telephone Co., Pittsburgh, Penn., to enter the consulting field. His work will include power-plant design, erection, testing and supervision. His address will be 3821 California Ave.

Frank R. Brosius, for the past ten years supervising engineer for the Columbus Ry. & Light Co., resigned on Jan. 1, to assume a similar position with A. B. Leach & Co., of New York, at Cincinnati, as supervising engineer of the power stations of the Cincinnati and Covington traction interests of that company. Mr. Brosius is a graduate of the State School for Soldiers' and Sailors' Orphans, at Xenia. He has been active in the organization of the local branch of the National Association of Stationary Engineers, and at its last meeting that organization adopted resolutions expressing their esteem for him and their regret that he is now to withdraw from the local organization. Mr. Brosius won the second prize offered by Power, Dec. 26, 1911, for the best practical article on "Running a Turbine."

Capt. Charles H. Manning, for more than thirty years superintendent of the mechanical and engineering departments of the Amoskeag Manufacturing Co., has resigned because of ill health. Capt. Manning is recognized among engineers as a high authority on steam, and the plants of the Amoskeag company testify to his engineering skill. He has been associated with such engineers as Haswell, Isherwood, Kafer, Loring, Melville and Thurston, and is known to steam engineers throughout the country. Capt. Manning was born in Baltimore, Md., June 9, 1844. His early education was received in Baltimore and Cambridge, Mass., and in 1860 he entered the Lawrence Scientific School of Harvard University to study civil engineering.

In 1861 he returned to Baltimore, and became an apprentice in the Reeder marine-engine works. In 1863 he was appointed third assistant engineer of the navy, where his knowledge and comprehensive grasp of scientific matters brought him to the attention of Chief Engineer Isherwood, who assigned him to the making of experiments on superheating steam on the "Adelaide" and other vessels. In 1870, Capt. Manning became an instructor at the Naval Academy and helped organize a course of instructions for cadet engineers, which is one of his most valuable achievements. He was a member of the first advisory board in 1881, which prescribed the first general characteristics of the warships of what was termed the new navy, and was the only engineer to vote for steel vessels. After 12 years of continuous duty he became mechanical engineer of the Amoskeag Manufacturing Co. During the Spanish-American war he was stationed at Key West as chief engineer of repairs. Capt. Manning had charge of all the Amoskeag company power plants, and was the architect and builder of the recently completed Coolidge mill. The steam units there installed have 65,700 nominal boiler horsepower, all of Capt. Manning's design. In 1885 Capt. Manning designed and installed a 2000-hp. horizontal water turbine, the first large installation of its kind. He also designed a 30-ft. flywheel, with a face of 108¼ in. and a thickness of 12 in. This rim was made up of 40 rings of ash. Capt. Manning has been consulting engineer for several other large mills. He is a past vice-president of the American Society of Mechanical Engineers, a member of the Army and Navy Club of New York, American Society of Naval Engineers, United States Naval Institute, American Society of Naval Architects and Marine Engineers, American Association for the Advancement of Science and the American Society of Cotton Manufacturing.